Compress

AUGUST 1953

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PHOTO, E. L. FISHER

COMPRESSED AIR UNDER THE SEA

New Development Takes Divers Out of Heavy Suits and Eliminates Hoses

(SEE INDEX PAGE AND PAGE 221)

VOLUME 58 • NUMBER 8

NEW YORK • LONDON

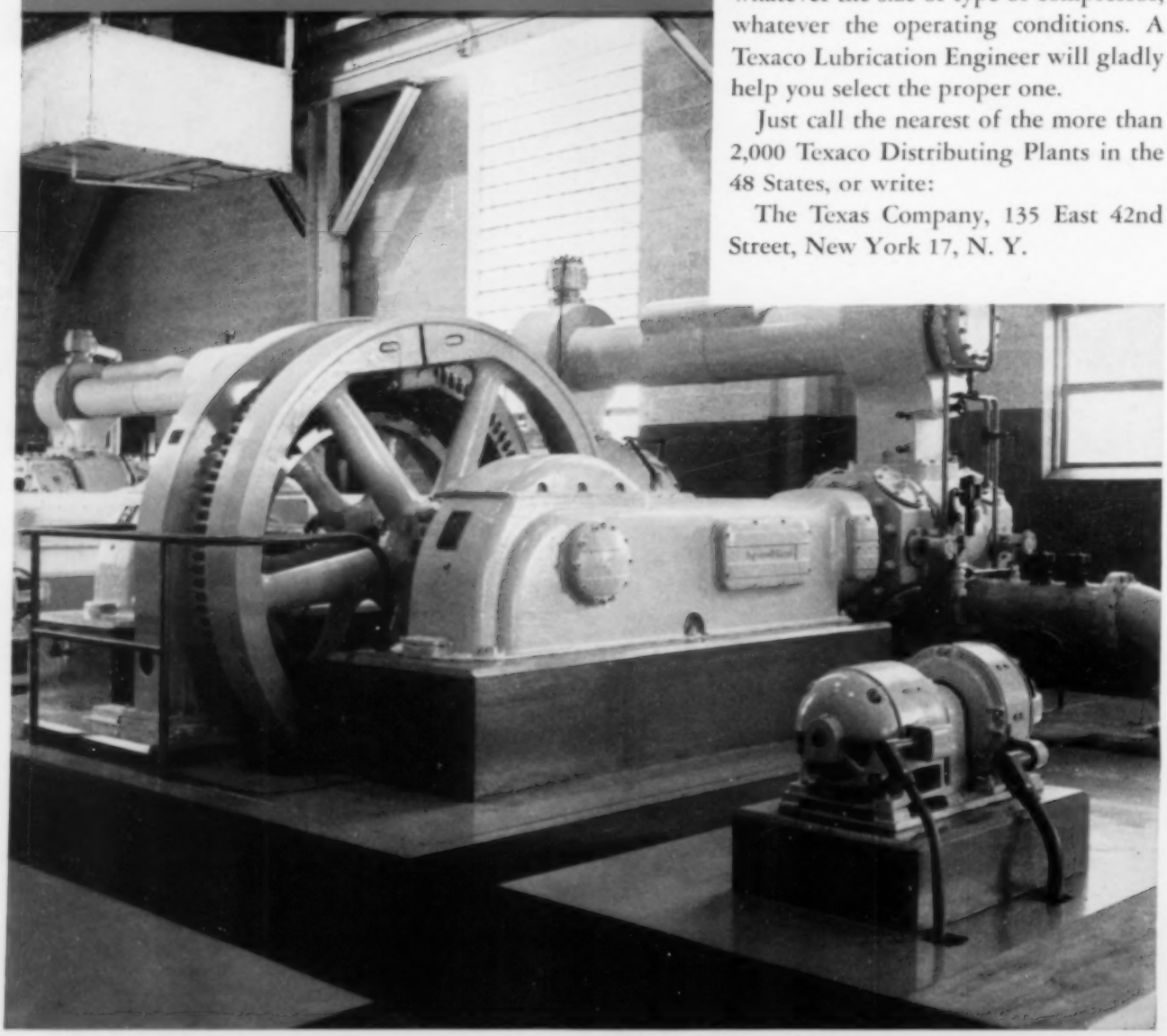
HOW TO KEEP COMPRESSOR SYSTEMS CLEAN

OPERATING CONDITIONS for air compressors vary from one installation to another. And *no one* oil can handle *all* of them. So your best bet for clean compressor operation is to use the oil that's exactly right for *your* compressors and *your* operating conditions. Texaco has it.

There is *a complete line* of Texaco air compressor oils to assure clean, efficient operation and low maintenance costs — whatever the size or type of compressor, whatever the operating conditions. A Texaco Lubrication Engineer will gladly help you select the proper one.

Just call the nearest of the more than 2,000 Texaco Distributing Plants in the 48 States, or write:

The Texas Company, 135 East 42nd Street, New York 17, N. Y.



TEXACO

TEXACO Air Compressor Oils

FOR ALL OPERATING CONDITIONS

STAYNEW INTAKE FILTERS GIVE

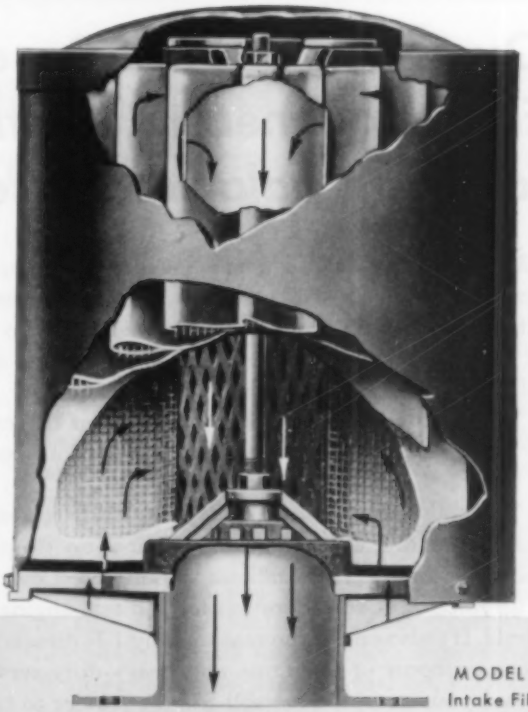
GREATER EFFICIENCY *plus* POSITIVE PROTECTION

IT'S A FACT! A filter which is 99.9% efficient is *9 times* as effective as one that is 99.0% efficient. Why?—because the filter that is 99.9% efficient lets only *one-ninth* as much dirt into the engine. And, it's the dirt that *gets in* that causes the trouble.

The extreme efficiency of Staynew Intake Filters provides *positive protection*—keeps shutdowns and repairs at an absolute minimum. Efficiency actually increases with use. Staynew Intake Filters are efficient over a wide range of loads and are not affected by temperature changes. And, Staynew Intake Filters effectively protect vital engine parts without carefully held maintenance schedules . . . frequently operating two or more *years* without attention.

Get all the facts. Write today for Bulletin S.I.F.

Representatives in Principal Cities



MODEL D
Intake Filter

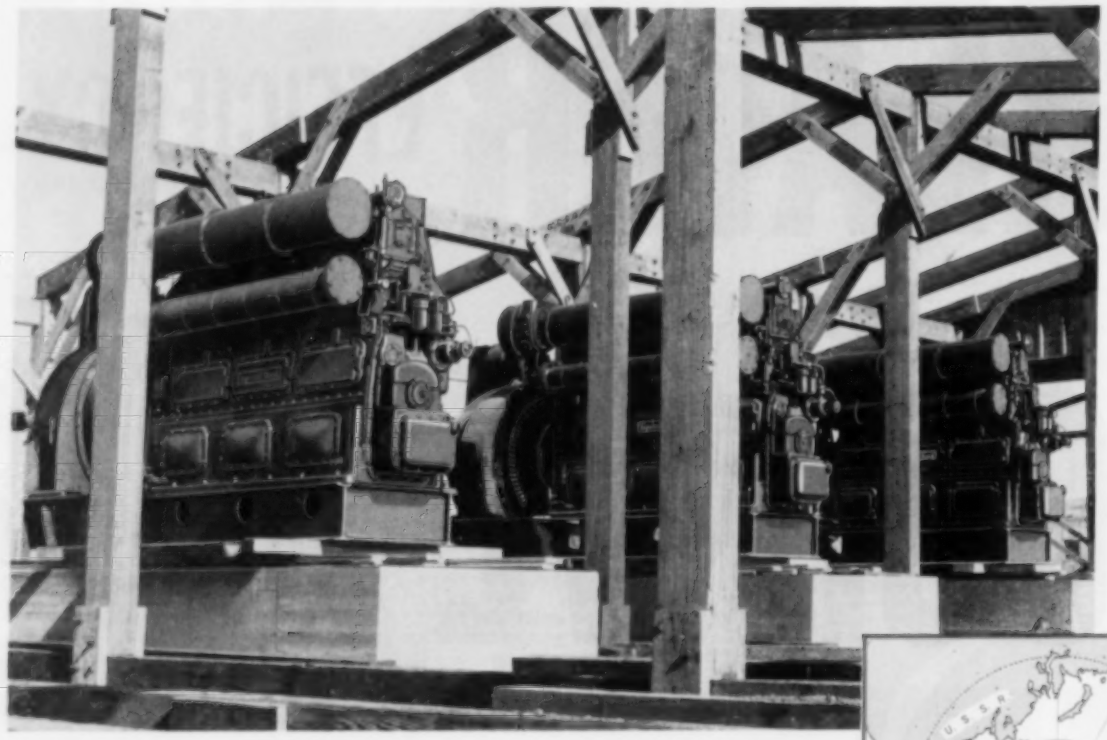
DOLLINGER
PROTECTO-MOTOR
STAYNEW FILTERS

DOLLINGER CORPORATION

7 Centre Park, Rochester 3, N. Y.

ALL TYPES OF FILTERS FOR EVERY INDUSTRIAL NEED

Sitting on top of the world



Over 30 Ingersoll-Rand Diesel Engines generate electric power for north polar air base . . .

Here at Thule – civilization's northernmost outpost, only 900 miles from the pole – the fierce arctic winter is 8 months long, with temperatures of 50 below zero and hurricane winds up to 150 miles an hour! At an isolated outpost like this, the traditional *dependability* of Ingersoll-Rand diesel engines is a tremendous asset.

The engines generate electric power for the new 480 acre American air base at Thule. Three of them are shown above during construction of one of the power plants.

The engines were shipped completely assembled. Their *compact design* and low weight-to-horsepower ratio simplified handling and installation under very difficult conditions. Low fuel consumption, too, is an important consideration for a diesel engine installation such as at Thule. It's also one of the reasons why I-R diesels are repeatedly selected when *economy of operation* and *heavy-duty service* must be combined.

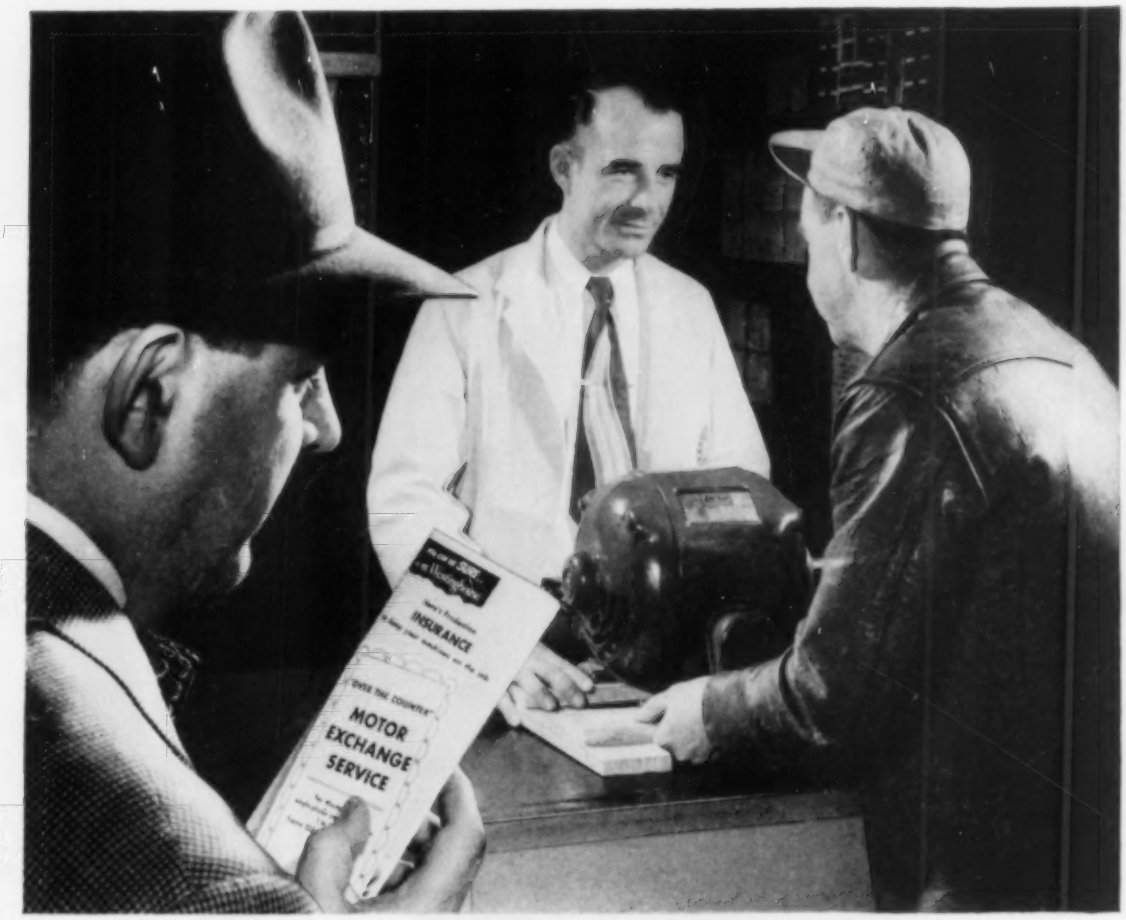
Ask your nearest Ingersoll-Rand engineer to tell you about the many other important advantages of I-R heavy-duty 4-cycle diesels – built in sizes from 200 to 900 hp.

946-7

Ingersoll-Rand
11 BROADWAY, NEW YORK 4, N. Y.

Construction of the diesel power plants at Thule was an ingenious solution to one tough problem called "perma-frost", a condition in which the earth a few feet below the surface is frozen to rock-like hardness. Ordinary building foundations were ruled out. The diesel-generator units were bolted to thick concrete slabs resting on piles set into the frozen ground. Buildings were constructed around them with floors laid on timbers above the ground. The underfloor air space insulates the building from the earth – and heavy concrete weights anchor the structures against the strong winds.

COMPRESSORS • ROCK DRILLS • AIR TOOLS • TURBO BLOWERS • CONDENSERS • CENTRIFUGAL PUMPS • DIESEL AND GAS ENGINES



Here's how to cash in a crippled motor for a fully guaranteed replacement

Through the Westinghouse Motor Exchange Plan, your company can release money tied up in stand-by motors and renewal parts . . . money that can be profitably employed in your own production. Under a most unique service policy, Westinghouse has set up a motor replacement pool for crippled motors. This Motor Exchange Plan makes available to you an immediate, fully guaranteed replacement for single or three-phase Life-Line* motors, under 20 hp, in frame sizes 203 to 326.

Quick over-the-counter replacement of Life-Line motors is handled at exchange points in 127 key manufacturing and production centers. If you are not located near such a warehouse, your local Westinghouse Sales Office will gladly expedite shipment of a replacement motor to your plant.

With fast service of this kind, you can substantially reduce or eliminate stand-by motors and renewal parts. You'll find, too, that using the Motor Exchange Plan will release maintenance, labor and equipment, necessary for repairing motor damage, to work on more important jobs.

Investigate the Motor Exchange Plan soon with your local Westinghouse Salesman. He will leave with you a complete description of the plan contained in this pamphlet, SM-5243; or write today for this information, Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pennsylvania. J-21743

*Trade Mark

YOU CAN BE SURE...IF IT'S

Westinghouse

THE ONLY MODERN FRONT END ... ON QUARRY SHOVELS

110-B, 4½ cu. yd.
150-B, 6 cu. yd.
190-B, 8 cu. yd.

Convertible Shovels — Draglines

THE new Bucyrus-Erie Ward Leonard electric shovels bring to quarry loading the first important departure from the old-fashioned shovel front end. This advanced design — with two-section boom, inside tubular handle, and quiet positive rope crowd — increases speed and payload. It reduces upper boom weight, puts extra strength in the lower section where maximum strength is needed. It cuts out old-style handle racking and crowd pinions, takes the deadweight of crowd machinery off the boom. And, most important to *you*, it gives you all these field-proven performance advantages:

- **Lighter Weight, Greater Strength** — Two-section boom, with light upper section . . . lower section strut-connected to the A-frame.
- **No Handle Twist** — Inside tubular dipper handle is free to rotate in rubber-cushioned saddle block.
- **No Handle Binding in Saddle Block** — Rope crowd is quiet, positive, eliminates handle racking and crowd pinions.
- **No Dipper Wobble** — Twin dual hoist ropes put hoist power where needed for steady travel of dipper through bank.
- **No Sway Braces** — Widespread boom feet eliminate accessory boom braces or cables.
- **Low Swing Loads** — Advanced front end design, with crowd machinery on deck, cuts dead load on swing, steps up swing speed.
- **High Pay Loads** — Single tubular handle — with improved dipper back connections, dipper trip on saddle block, no dipper bail — reduces dead load on hoist, leaves more power for digging. 31L53C

There's much more to the story, too. Deck machinery, electrical equipment, and mounting all match the front end in advanced engineering and outstanding performance advantages. The full story will convince you that yard for yard, dollar for dollar, pound for pound, these are the finest rock excavators ever built.

Write for Complete Information Today!

BUCYRUS ERIE

BUCYRUS-ERIE COMPANY SOUTH MILWAUKEE, WISCONSIN

SWITCH TO GM DIESEL

Ingersoll-Rand Gyro-Flo 600, driven by GM 6-71 Diesel, powers two wagon drills in New Jersey quarry.

FOR PORTABLE AIR POWER AT LOWER COST

CONTRACTORS, utilities, mine and quarry operators who have switched to General Motors Diesel-powered Gyro-Flo compressors unanimously report they get *"more work done faster at lower cost!"*

Basic reason is that this modern rotary compressor takes full advantage of GM Diesel's higher-speed 2-cycle operation. Because it delivers power at *every* downstroke of every piston, not every *other* downstroke as do 4-cycle Diesels, the GM Diesel produces a smoother, steadier flow of power. And this means full-rated delivery of even-flowing, non-pulsating cooler air at 100 psi and better.

The GM Diesel starts quickly in any weather and maintains its rated power well at high altitudes. Two-cycle design makes it smaller and lighter for its power. This permits lighter, more compact equipment with all the advantages of greater mobility.

Add to these features interchangeability of low-cost parts, plus world-wide General Motors Diesel service facilities, and you have reasons why it pays to standardize on GM Diesel power in all your equipment. Available today in all four sizes of Ingersoll-Rand Gyro-Flo compressors—105, 210, 315 and 600 cfm—and in more than 750 models of other equipment built by over 150 different manufacturers. *Save money—specify GM Diesel!*

Single Engines...16 to 275 H.P. Multiple Units...Up to 840 H.P.

GM GENERAL MOTORS DIESEL POWER

DETROIT DIESEL
ENGINE DIVISION
GENERAL MOTORS • DETROIT 28, MICHIGAN

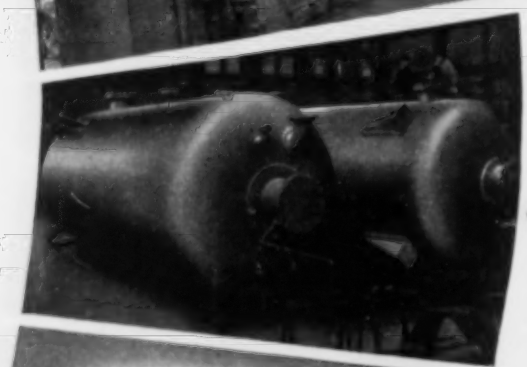
USE THESE BETTER

Vogt Products

For Today's Tough Service Demands

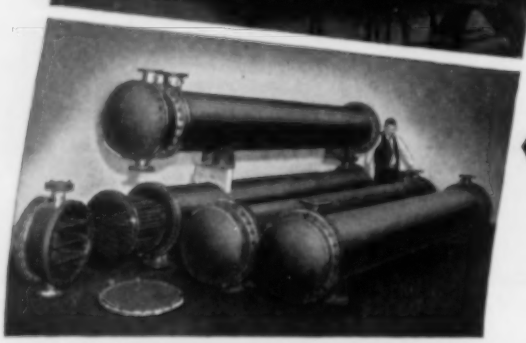
EFFICIENT AND DEPENDABLE STEAM GENERATION

Vogt steam generating units are designed to give maximum rating in a minimum of space with high efficiency and low maintenance expense. Bent tube types and straight tube, forged steel sectional header types to burn solid, liquid or gaseous fuels, as desired, meet every power, heating or process requirement.



PROCESS EQUIPMENT FOR EVERY SERVICE

Stills, towers, oil chilling machines, filter presses, heat exchangers, etc. are constructed to all Codes. They meet all demands for operating security and trouble-free performance and help to lower costs in important process industries around the world.



SPECIAL MATERIALS FIGHT CORROSION AND PRODUCT CONTAMINATION

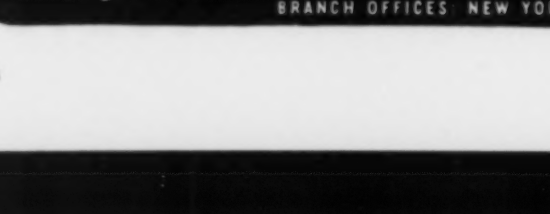
Our modern shops produce a wide variety of equipment made from special metals and alloys to combat corrosion, and product contamination or discoloration. Fabrication procedures employed insure that corrosion resistant properties of welds will match that of the materials from which units are constructed.

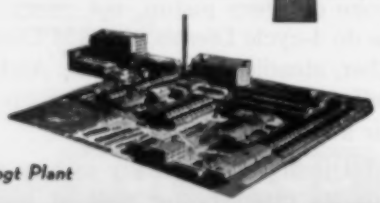
MORE TONNAGE AT LESS COST

Over 60 years of manufacturing experience, engineering and research stand behind Vogt refrigerating and ice making machinery. Absorption Systems, Compression Systems, and the Automatic Tube-Ice Machine in a wide range of capacities serve in leading petroleum refineries, chemical plants, ice and cold storage plants, dairies, packing plants, etc., at home and abroad.

DROP FORGED FOR EXTRA TOUGHNESS AND LONG-TIME SERVICE

Vogt valves, fittings and flanges, for top performance in oil, water, air, gas, and ammonia services, at high or low pressures and temperatures, are available drop forged entirely from carbon steel or stainless steel. Valves can be furnished in a combination of materials by using stainless steel for parts affected by service temperature or corrosion, and less expensive alloys or carbon steel for other parts.





Air View of Vogt Plant

HENRY VOGT MACHINE CO.

LOUISVILLE 10, KENTUCKY

BRANCH OFFICES: NEW YORK, PHILADELPHIA, CLEVELAND, CHICAGO, ST. LOUIS, DALLAS

Wire Rope at Work—Near Hazleton, Pa., lie rich seams of anthracite coal which in places are not far below the surface of the ground. The dragline excavator shown here, owned by A. E. Dick Contracting Co., is getting at the coal by stripping off overburden—the cover of earth that is about 120 ft in thickness at this particular point.

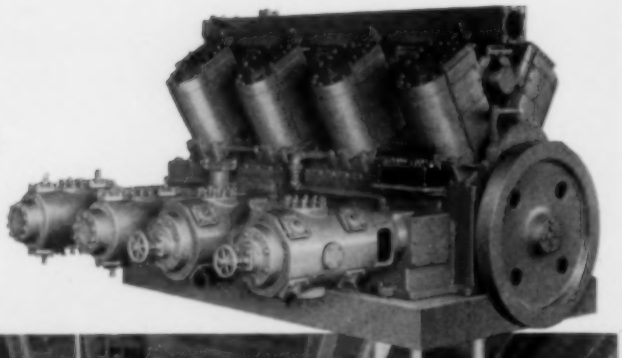
Using a 22-yd bucket, the excavator can scoop up thousands of cubic yards of dirt and rock per day. It works 'round the clock, with only minor interruptions. This mechanical mastodon is fitted throughout with Bethlehem Wire Rope, including twin draglines and hoist lines, visible in the picture as they handle the bucket. A typical assignment, the kind of rough, tough job entrusted to Bethlehem rope in every type of industry, wherever there is heavy lifting or hauling to be done.

Bethlehem Steel Company, Bethlehem, Pa. On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. Export Distributor: Bethlehem Steel Export Corporation

Mill depots and distributors all over the country stock Bethlehem rope for the following industries and numerous others:
MINING • CONSTRUCTION • PETROLEUM • EXCAVATING • QUARRYING • LOGGING • MANUFACTURING

at Snyder Plant of

STANDARD OIL COMPANY of TEXAS



7 VETERAN (16 years old) XVG's + 8 MODERN SVG's = 5340 hp of trouble-free casing head gas compression

The 15 Ingersoll-Rand gas-engine-driven compressors shown above include seven XVG units which have been in almost continuous operation since 1936 . . . plus eight modern-design SVG units. The XVG's were moved to Snyder Plant in West Texas from an old plant in Ward County, requiring remarkably little work at the time of relocation.

Old and new units alike are all giving *excellent service,* compressing casing head gas to 465 psig pressure for delivery to the absorbers.

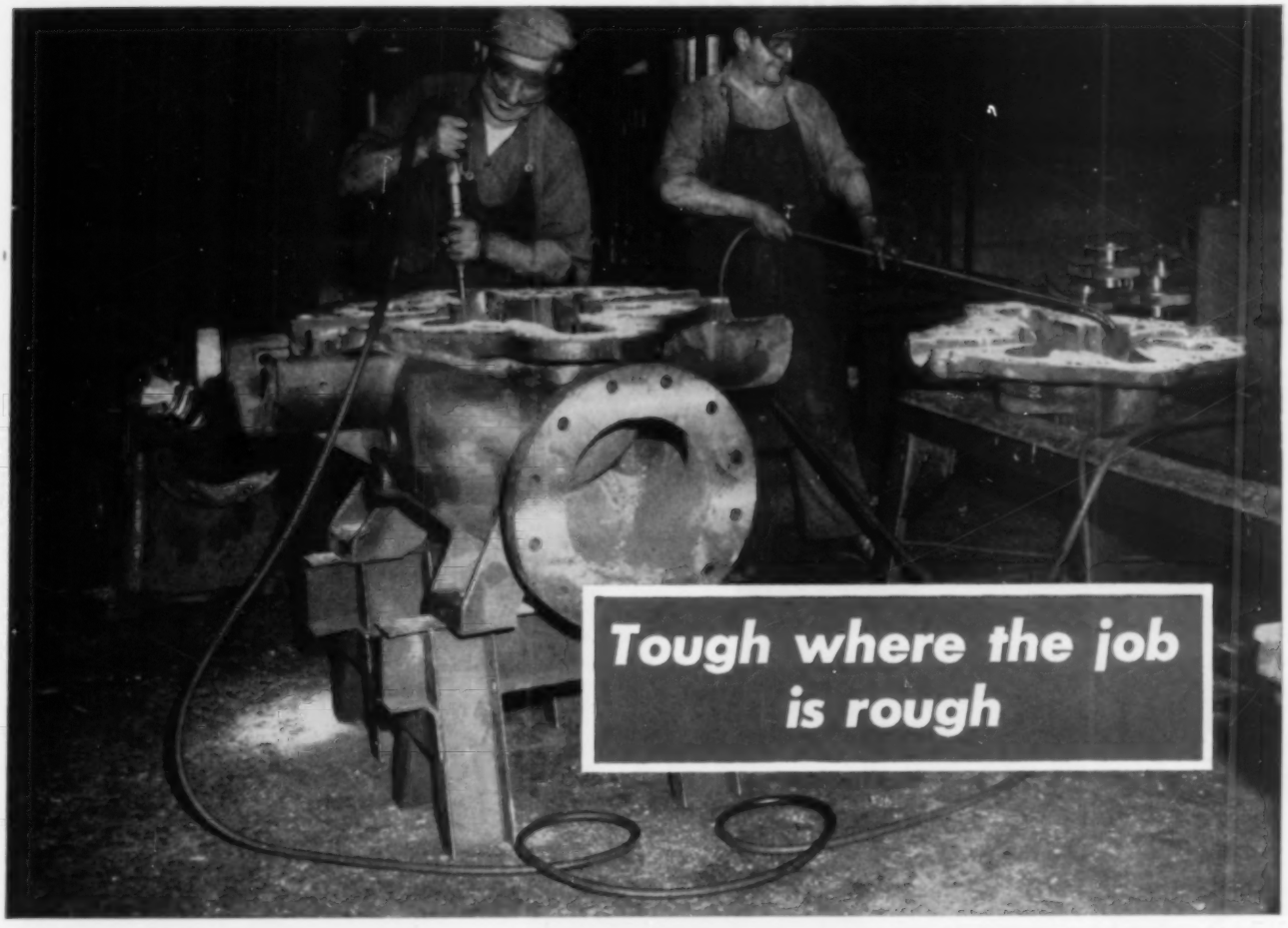
The seven XVG's are rated at 260 hp each and the eight SVG's at 440 hp each—a total of 5340 hp.

Ask your Ingersoll-Rand representative for complete information on gas-engine compressor performance and economy.

Ingersoll-Rand
11 BROADWAY, NEW YORK 4, N. Y.

850-6

COMPRESSORS • AIR TOOLS • ROCK DRILLS • TURBO BLOWERS • CONDENSERS • CENTRIFUGAL PUMPS • DIESEL AND GAS ENGINES



Air hose with tube and cover of NEOPRENE gives outstanding service in plant operations

To keep a two-step operation like polishing pump casings moving on schedule, men need dependable equipment. For example, the hose that supplies compressed air for the grinders and air guns must be rugged enough to take constant flexing and abrasion. It gets twisted and pulled around sharp corners . . . dragged across oily floors littered with razor-sharp metal chips. At the same time the tube is continually threatened by hot, oil-laden air. But here's an air hose that thrives on rough handling. It's made inside and out with Du Pont neoprene.

THE COVER OF NEOPRENE is tough and durable . . . resists oil, abrasion, cutting and chipping . . . provides the fabric reinforcement with maximum protection throughout its long life.

THE NEOPRENE TUBE won't go to pieces when exposed to hot lubricating oil in the air stream. No crumbled particles are carried along to clog vital tool parts. And neoprene's toughness and flexibility assure long, trouble-free service under the most adverse conditions.

DU PONT SUPPLIES neoprene to air-hose manufacturers who use it in their top-quality lines. Ask your supplier about hose with tube and cover of neoprene. He'll be glad to show you how it's built for rugged service.

FREE! The Neoprene Notebook
Each issue brings you new, unusual applications of neoprene . . . new products . . . interesting stories. Send in the coupon below to get on the mailing list.

NEOPRENE

The Rubber Made by Du Pont Since 1932

DU PONT

REG. U. S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

E. I. du Pont de Nemours & Co. (Inc.)
Rubber Chemicals Division CA-8
Wilmington 98, Delaware

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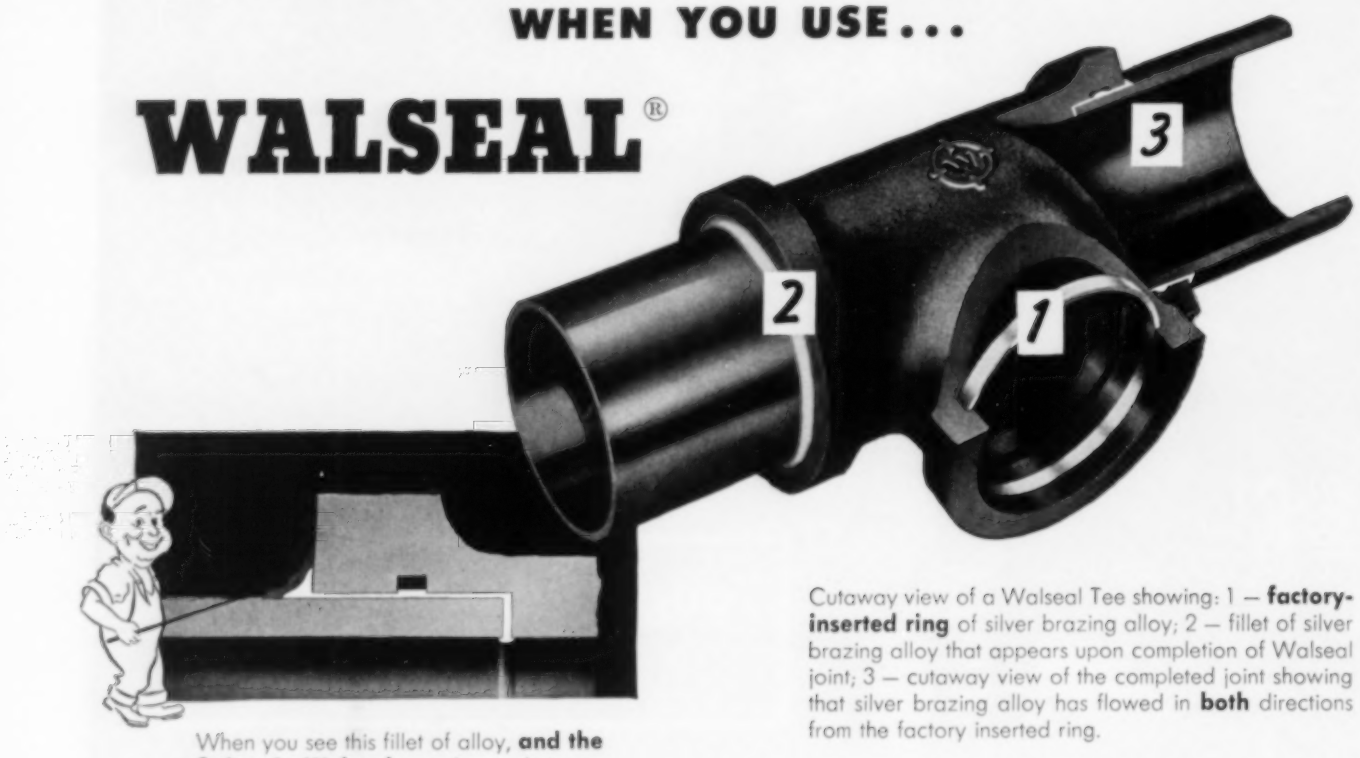
WHEN YOU USE...

WALSEAL®



When you see this fillet of alloy, **and the fitting is Walseal** you know that you have full penetration because the alloy comes from the inside.

Cutaway view of a Walseal Tee showing: 1 — **factory-inserted ring** of silver brazing alloy; 2 — fillet of silver brazing alloy that appears upon completion of Walseal joint; 3 — cutaway view of the completed joint showing that silver brazing alloy has flowed in **both** directions from the factory inserted ring.

When you join brass, copper, or copper-nickel pipelines with Walseal Valves, Fittings, or Flanges you know you have the *right amount* of the *correct type* of silver brazing alloy. The ring of Sil-Fos brazing alloy is *factory-inserted* in the ports of Walseal products at the time of manufacture.

No lost time or motion in handling the alloy . . . no difficulty in getting *full penetration* of the alloy regardless of the position of the valve or fitting . . . no guessing whether the joint is made right . . . the fillet of silver brazing alloy that shows up when the Walseal joint is completed, *comes from the inside!* And, whether you've made the joint yourself, or are inspecting the work of another, you know that if the silver alloy fillet is visible, *and the valve or fitting is Walseal,* you have full penetration. That's why nobody guesses when you use Walseal!

Walseal products are backed by the reputation of the Walworth Company, manufacturers of valves and pipe fittings since 1842.

For full information regarding silver brazed joints made with Walseal products, write for Circular 115.

SEE OUR CATALOG IN SWEET'S

Recommended for

Hot and Cold Water Circulating Systems

Boiler Feed Lines

Steam Return Lines

Condensate Lines

Low and High Pressure Air Systems

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Solvent and Vacuum Piping Systems

Make it "a one-piece pipeline" with WALSEAL

WALWORTH

valves and fittings

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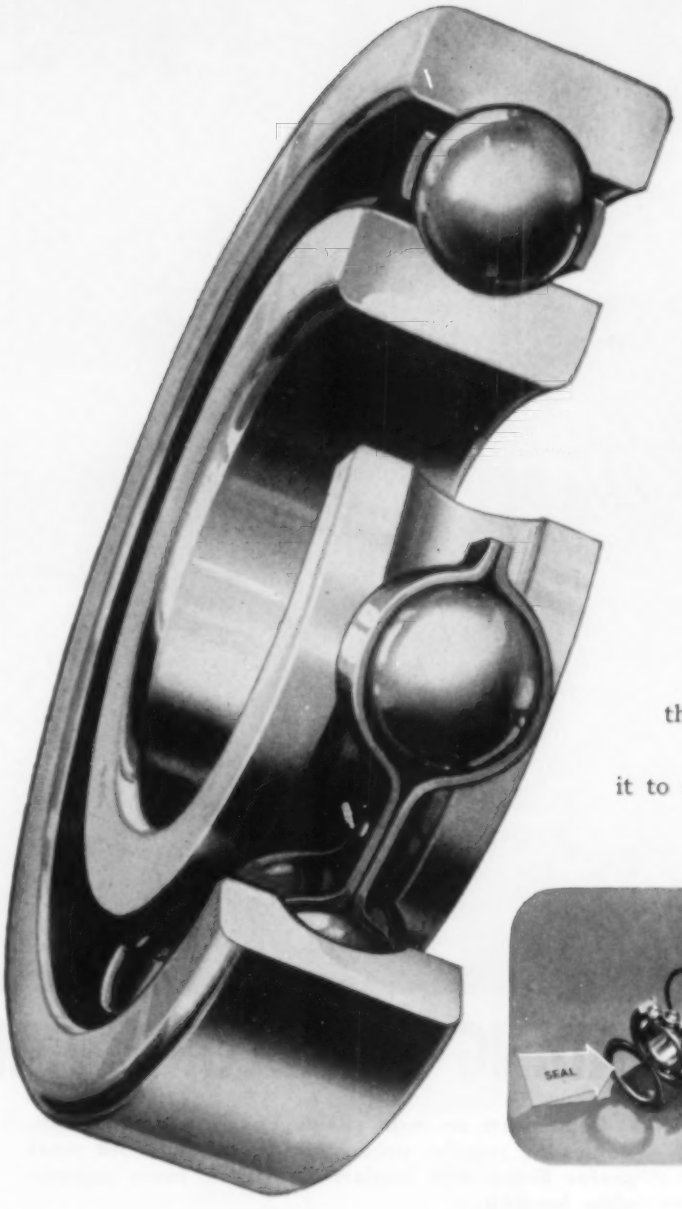


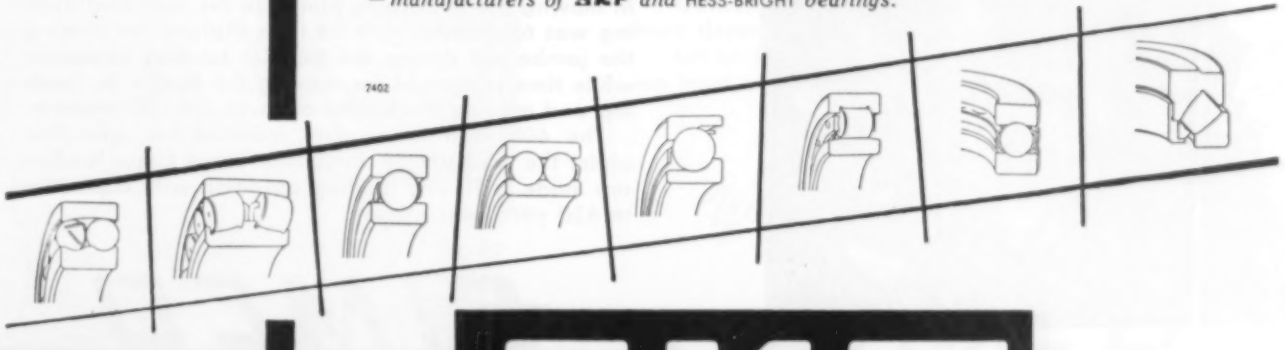
where shafts must turn fast you'll find SKF SINGLE ROW DEEP GROOVE BALL BEARINGS

Look at the *contact* between the balls and the deep, continuous groove in each ring of this SKF bearing—contact that enables it to sustain not only radial load, but substantial thrust load, even at very high speeds.

Look further—SKF Single Row Deep Groove Ball Bearings are available with *any combination* of DuPont Fairprene seals, shields and snap rings: shields for excluding dirt; seals for retaining lubricant; snap rings for holding the bearing in lateral position in its housing.

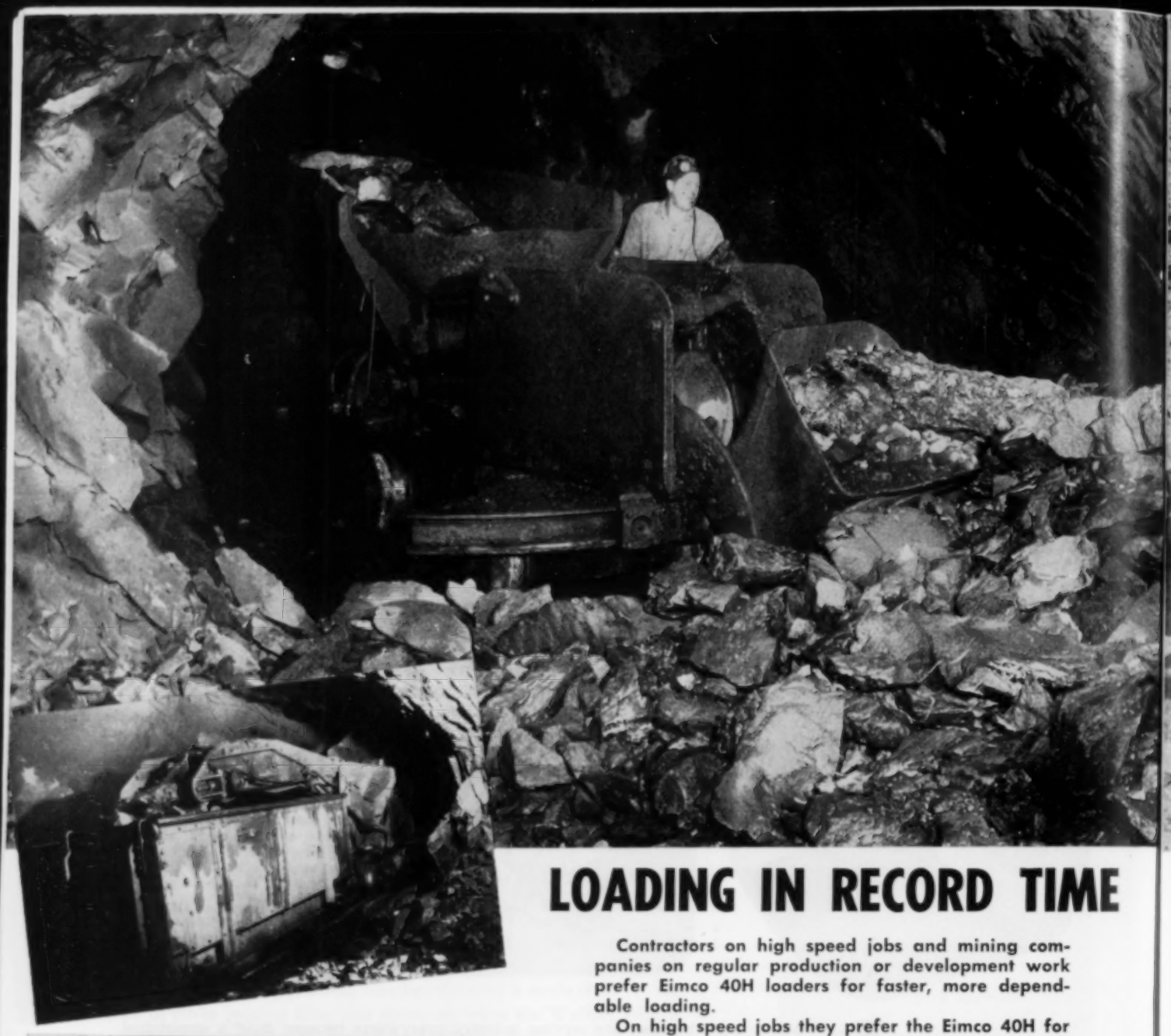
Like all SKF Bearings, they're held well within established tolerance limits, tested for radial runout, carefully cleaned, protected from rust, strongly packaged.

Many SKF bearings are serving industry everywhere because SKF's unmatched Field and Home Office engineering service helped product designers *put the right bearing in the right place.* **SKF INDUSTRIES, INC.,** PHILADELPHIA 32, PA. *—manufacturers of* **SKF** *and* HESS-BRIGHT *bearings.*



SKF'S COMPLETE LINE OF ANTI-FRICTION BEARINGS, PLUS **SKF** ENGINEERING CO-OPERATION, HELPS YOU PUT *THE RIGHT BEARING IN THE RIGHT PLACE.*

SKF®
BALL AND ROLLER BEARINGS



LOADING IN RECORD TIME

Contractors on high speed jobs and mining companies on regular production or development work prefer Eimco 40H loaders for faster, more dependable loading.

On high speed jobs they prefer the Eimco 40H for maximum loading of large cars and to keep the loading portion of the cycle shorter than drilling time.

On a recent high speed tunnel the time consumed in moving the 5 machine jumbo to the face and drilling was 65 minutes with no time charged for moving the jumbo out during the powder loading operation while time consumed for moving the loader in, loading and moving the loader out was only 55 minutes.

The 40H is a heavy-duty machine for operation under the most severe conditions. Other Eimco loaders are made to fit any loading condition with capacities to 450 yards per minute.

EIMCO 4469

Eimco 12B

Eimco 21

Eimco 104

THE EIMCO CORPORATION

The World's Largest Manufacturers of Underground Rock Loading Machines

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ROUGH—TOUGH JOBS—SPECIFY EIMCOS

When jobs are tough — it's more imperative than ever that an Eimco be selected to do the job.

Eimcos are built heavy, for dependable operation on the roughest, toughest jobs; for handling rock, sticky clay, gravel or any combination of hard to load materials.

With Eimcos you get a faster loading cycle — forward to dig and load back to discharge into the truck or railroad car. This action makes it easier on tracks and rollers for less maintenance and repair.

Quantities loaded can run from 300 to 350 yards per hour depending on your conditions.

Let an Eimco representative show you a machine working near you. Write for more information.

You can't beat an Eimco

EIMCO

A470

THE EIMCO CORPORATION

The World's Largest Manufacturers of Underground Rock Loading Machines

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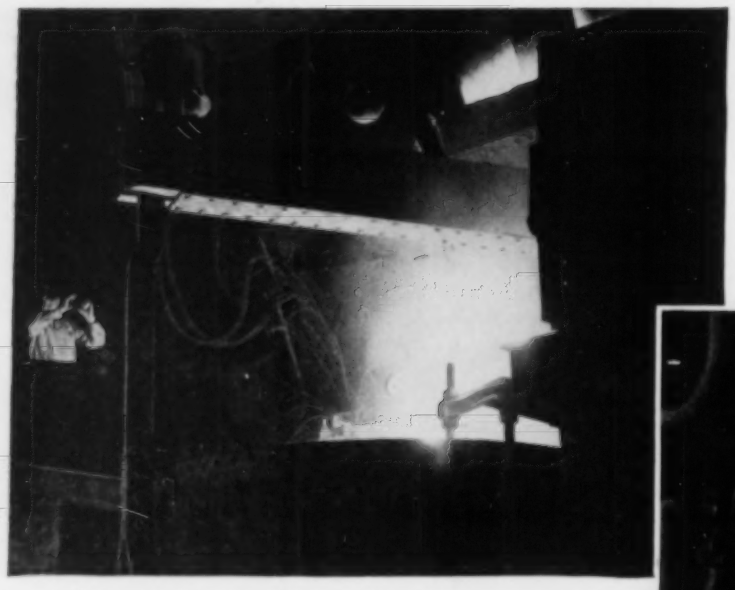
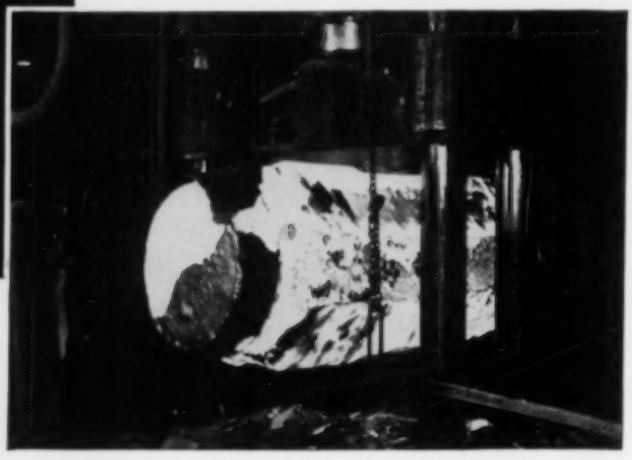
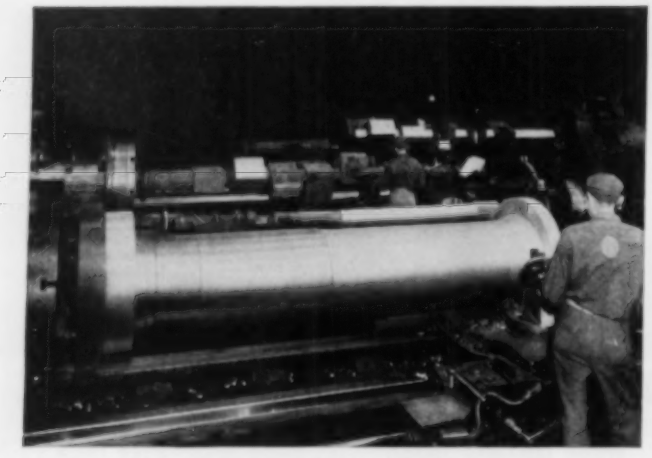
HERE'S THE STORY OF YOUR FORGINGS AT NATIONAL FORGE AND ORDNANCE CO.



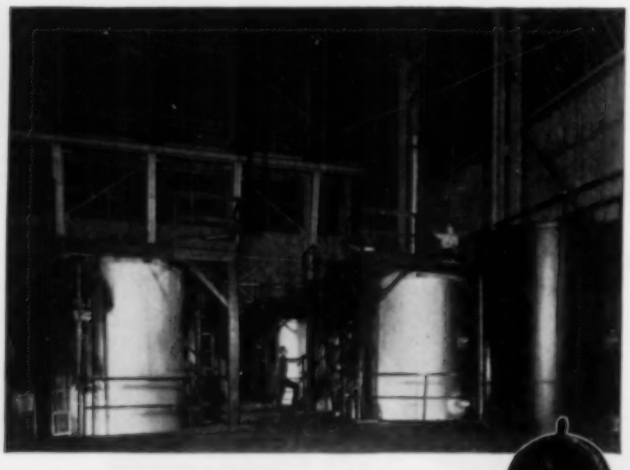
1. Basic Electric Steel is made for all forgings.



2. Forgings are made from Ingots of proper size for the best final result.



3. Forgings are rough-machined before heat treatment to insure greatest uniformity.



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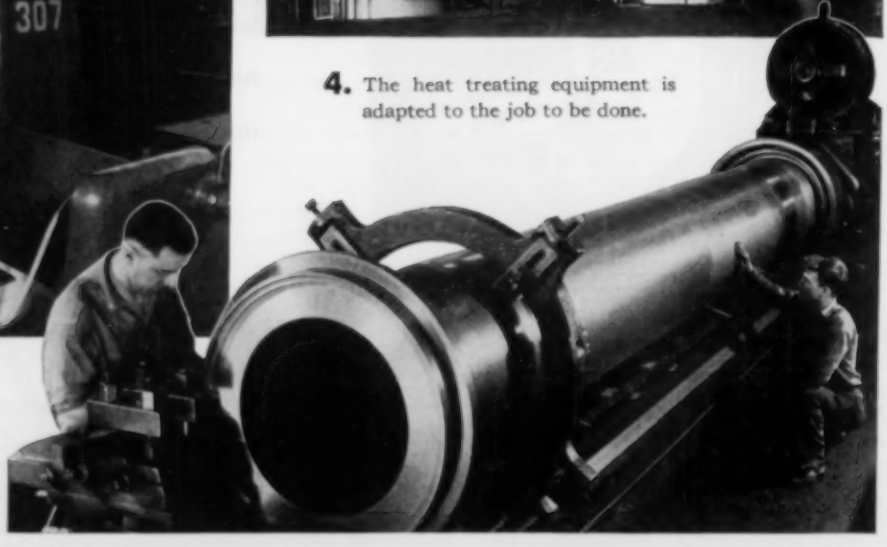

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ON THE COVER

NO ONE ever thought a man would some day be able to pursue fish underwater and then kill them with a gun that shoots steel shafts, but there is proof on our cover that the time is here. The picture depicts a wearer of an Aqualung swimming freely under the surface of the sea, breathing air that he carries on his back and towing a specimen of the finny tribe that has fallen prey to a weapon that is fired with compressed gas. More about this remarkable new development will be found farther along in the issue.

IN THIS ISSUE

A TREATY signed in 1950 provides for possibly trebling the production of hydroelectric power at Niagara Falls, with the additional generating facilities to be divided about equally between the United States and Canada. Thus far, we have done virtually nothing towards turning out our share of the kilowatts, because we haven't been able to decide whether some branch of the government or private power companies should do the job. Last month a committee in Congress approved a bill that would authorize private capital to go ahead, but the measure still faces a rocky road before it passes. Meanwhile, as recounted in our leading article, which is the first of two parts, Canada is well advanced on the construction of a new plant that will provide 1,200,000 hp.

•

THE efficiency and economy of modern earth-and-rock excavating equipment is brought into sharp relief by the story of what the DeBardeleben Coal Corporation is accomplishing in Alabama. To mine a 2-foot layer of coal, it is removing 40 feet of overburden, mostly rock. The secret of its success is the size of the operation. A Quarrymaster drill puts down 80 to 100 feet of large-diameter blast hole per hour, and the broken material is cast off the coal seam by one dragline at a rate of 10,000 cubic yards a day. It's a big job, being done in a big way. Page 218.

•

A DIVER need no longer be encumbered with a stiff lead-weighted suit and long hose lines to bring him breathing air from the surface. A new device, the Aqualung, lets him carry his air supply under high pressure and permits him to frolic like a fish. A smooth-working regulating valve feeds air to him in accordance with the demands of his lungs. Page 221.

Compressed Air Magazine

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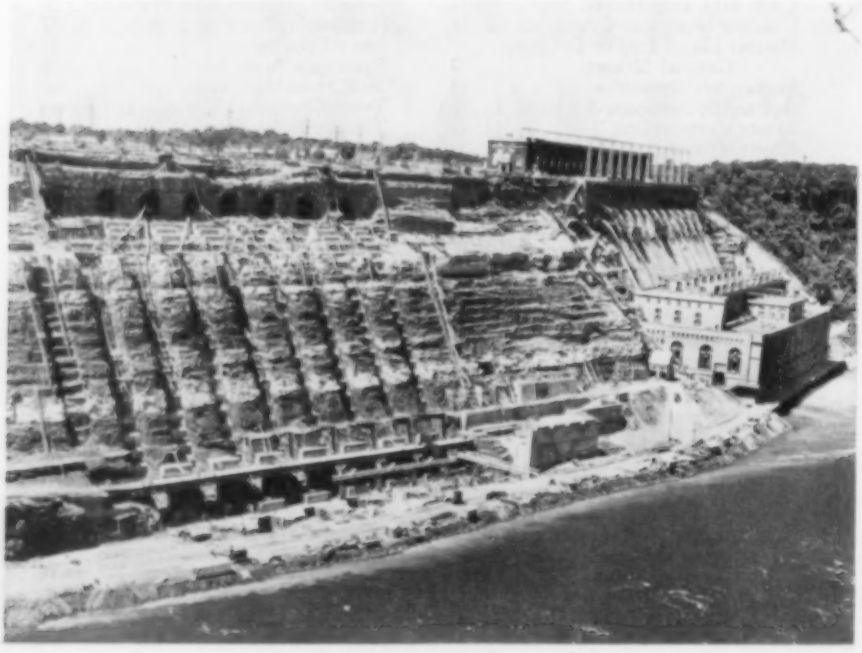
More Canadian Kilowatts at Niagara

Work is Well Advanced on New 1,200,000-hp Generating Plant Below the Falls

H. R. Rice

PLAN AND PROFILE

The large drawing shows the respective locations of the structures now being provided and those of the existing Sir Adam Beck Generating Station No. 1. Water for the latter travels a circuitous route in open river and canal, whereas the current scheme calls for twin tunnels under a thickly populated urban section and a canal for the remainder of the distance. Work is spread over a length of 8 miles and an area of 8000 acres. Three conveniently located camps provide living facilities for 3000 men. Twenty-five miles of roads were built to reach disposal areas aggregating 640 acres that are receiving the 29 million tons of earth and rock to be excavated. To supply the 1,419,000 cubic yards of concrete called for, a mixing plant is located at each end of the project. The profile (top) shows the tunnel line of varying depth and the five shafts that give access to it.

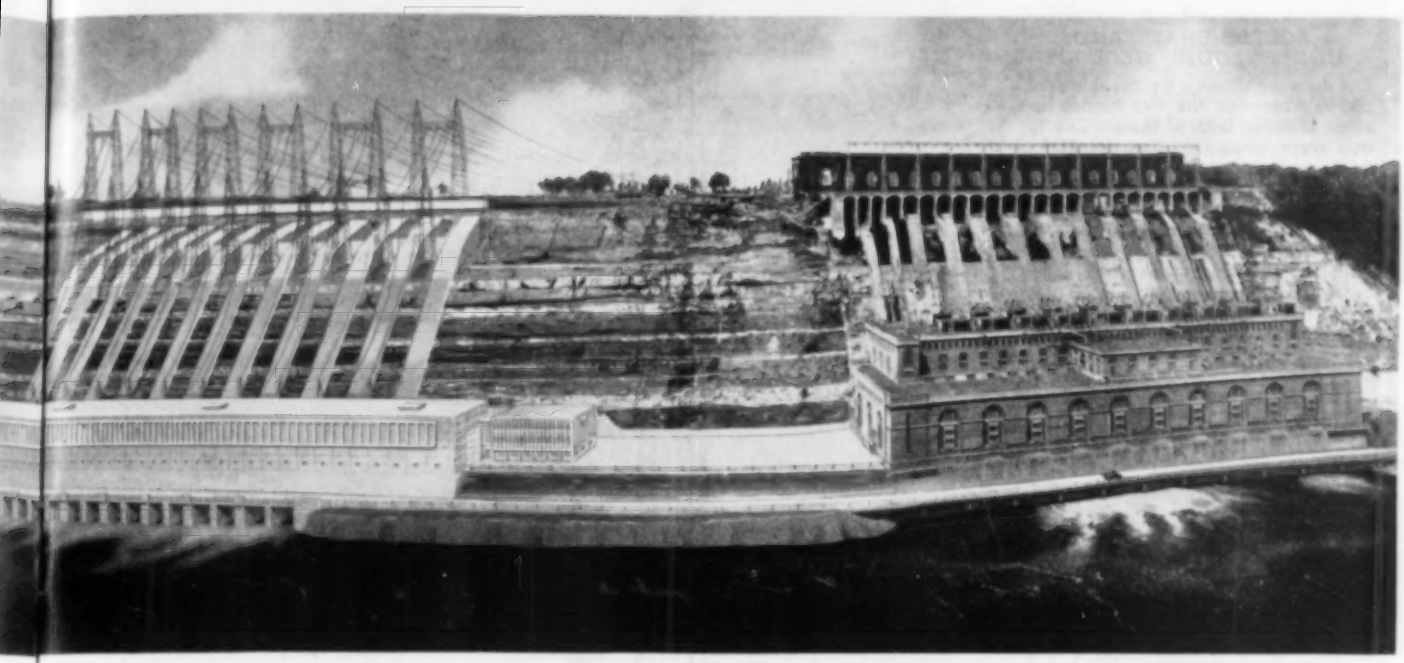


TAKING FORM

Crowding its way into the rather limited space, No. 2 station is gradually taking shape just upstream from its 31-year-old neighbor. High on the cliff may be seen the black circular openings from which water will emerge to enter the penstocks. The powerhouse will be 63 feet wide, 60 feet high and 931 feet long when all twelve of its 500-ton generators are in place.

Part 1

MENTION of Niagara Falls immediately conjures up a vision of the most spectacular tourist attraction on this continent in terms of the number of people who go there each year to view the spectacle and to round out their visits in the many short tours to other scenes along this mighty waterway, all of which provide aesthetic delight to millions. Less well appreciated, at least by the general public in the United States, and for rather valid reasons, is the great economic import to both the States and Canada of the power of Niagara's



THE NEW LOOK

On a photograph of the existing powerhouse, right, an artist has drawn the new and larger neighboring structure as it will appear when completed. Sir Adam Beck, for whom both stations are named and who is called the father of Ontario's Hydro-Electric Power Commission, was once ridiculed for predicting that the Niagara River would some day yield a million horsepower of energy. These two plants alone will have a combined installed capacity of 1,725,000 hp.

waters flowing at a rate of about 200,000 cubic feet per second and dropping some 326 feet in their 35-mile passage from Lake Erie to Lake Ontario. The energy expended in this descent amounts to nearly 8,000,000 hp, a fact that has intrigued the minds of progressive men in both countries for two centuries.

It was not until the latter part of the nineteenth century, however, that development at Niagara could be seriously considered. For it was then that the well-known controversy between Thomas A. Edison and George Westinghouse as to the relative merits of direct-current and alternating-current generation came to an end and it was resolved to everyone's satisfaction that it was more economical to use alternating-current equipment and to transmit the energy to distant points of consumption.

The topographic and geological features of the Niagara River are such that any attempt to harness even some of its power entails engineering works of considerable magnitude, and they preclude any scheme involving purely mechanical transmission. The capital outlays necessary for the construction of plants to produce electricity for local use in the relatively limited industrial establishments in the immediate vicinity at the turn of the century were prohibitive, and it was apparent that any development would have to be undertaken with the idea of serving larger areas and distant centers of population and industry.

Indeed, the first generating station to take advantage of some of the difference in elevation between Lakes Erie and Ontario was built at DeCew Falls on Twelve-Mile Creek, so named because it is that far west of the Niagara River. There, in 1897, one of the first Canadian "high-head" hydroelectric plants was put into operation. In recent years this installation was augmented by a new powerhouse, bringing the peak capacity at this site to about 201,000 hp.

The history of the DeCew Falls station goes back to the days when one John de Cou, a man of Huguenot French descent who made his way to Canada with other United Empire loyalists in the years following the American Revolutionary War, acquired a number of lots along Beaver Dam Creek. That was in 1788. After serving in the War of 1812-14 he became interested in obtaining more water for mills he had constructed along Beaver Dam and Twelve Mile Creek. The plan he had in mind involved diverting water by a canal system from the Welland River to the creek, and even though it was not carried out in his lifetime or for its original purpose, it did stimulate thought about the original Welland Ship Canal—the first of a series of waterways of which the most modern one is among the world's busiest arteries of commerce.

The 1897 DeCew Falls plant followed by less than 25 years the first experimental dynamo, the electric motor, and the incandescent lamp and paved the way for the creation of a string of powerhouses on the Canadian side of the Niagara River that is reaching its culmination in the Sir Adam Beck Generating Station No. 2, certain structural features of which are the subject matter of this series of articles.

The first powerhouse at Niagara was erected on the Canadian side by the old Electrical Development Company whose "Toronto" station was placed in service in 1906 and utilized but 137 feet of the head available at the Falls and Upper Rapids. Other private interests who built plants on the Canadian shore during the first decade of the century included the Canadian Niagara and the Ontario Power companies, and only the one operated by the last concern utilizes 180 feet of the estimated 217-foot head at the Horseshoe Falls and Upper Rap-

Highlights of Scheme

Name: Sir Adam Beck-Niagara Generating Station No. 2.

Operating plan: Water taken from the river above the Falls will be conveyed through tunnels and a canal to a powerhouse 6 miles downstream from the Falls.

Generating equipment: Twelve units with an installed capacity of 900,000 kw (1,200,000 hp) to be placed in three stages of construction: five units scheduled for operation in 1954, six in 1955, the remaining one in 1956.

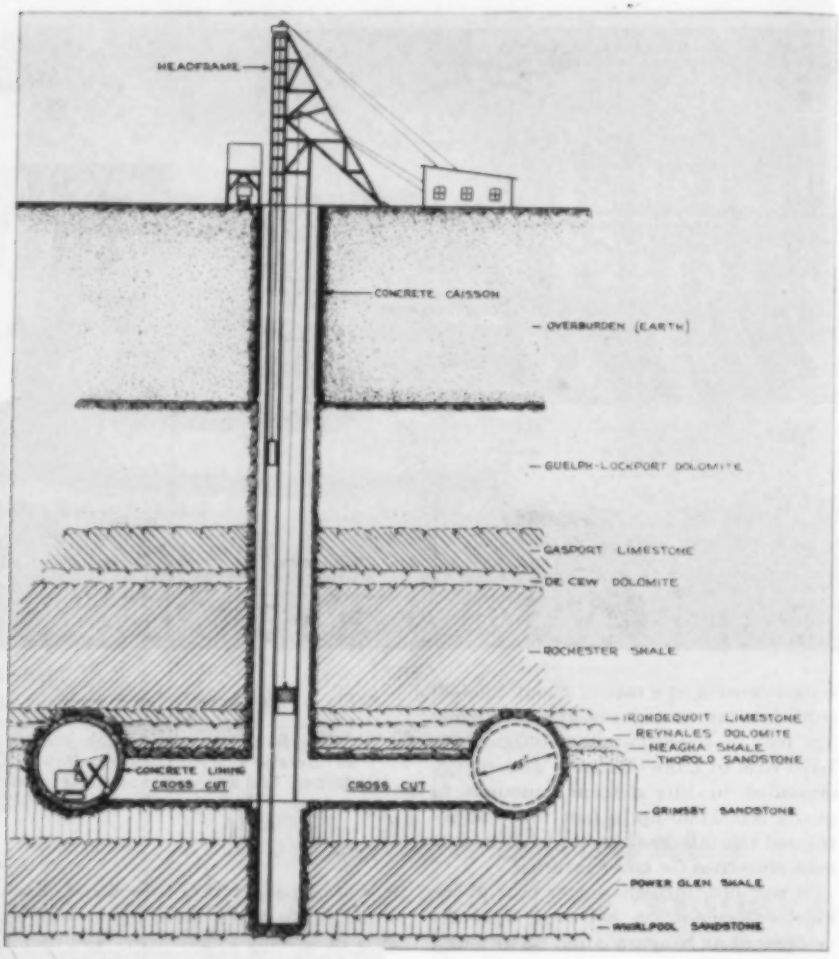
Engineering features: Tunnels are largest (51 feet as excavated) of their length (5½ miles) ever driven. Canal will be wider and deeper than Suez. When in full operation, the power plant will utilize 15,000,000 gpm of water.

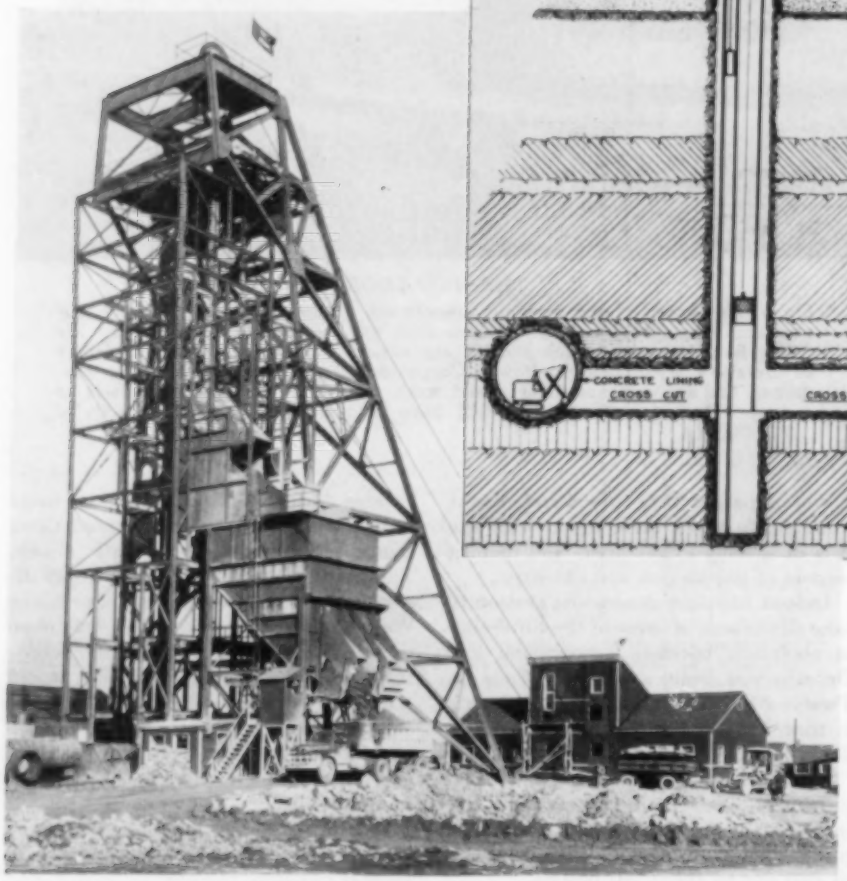
Sponsor: The Hydro-Electric Power Commission of Ontario.

Cost: More than $300,000,000.

ACCESS SHAFT AND UNDERGROUND GEOLOGY

The drawing shows a typical shaft, sunk midway between the two tunnel lines so as to serve both of them. The tunnels were located so that the 10-foot-thick and structurally sound Irondequoit limestone would form their roofs. The headframe at Shaft No. 3 (below) rises 125 feet and contains 250 tons of steel. Its 2⅛-inch cables can lift a load of 50 tons, but loads are usually held to 20 tons or less. Most of the nine million tons of rock to be excavated from the two tunnels is being handled through the five shafts.





ids. In the order named, and with additions made over the years, the capacities of these powerhouses are: 145,000 hp, 108,000 hp, and 181,000 hp.

Contemporary construction on the American side consists of the Schoellkopf and Adams stations which, with enlargements and alterations, are rated at 483,000 hp and 107,000 hp, respectively. They were built with private capital by the old Niagara Falls Power Company and have been owned and operated by it and its various successors, the Niagara-Hudson and the present Niagara-Mohawk Company.

In 1922 the Hydro-Electric Power Commission of Ontario put into use the plant at Queenston, known as the Sir Adam Beck Generating Station No. 1, which now has an installed capacity of 525,000 hp and operates under a normal gross head of 315 feet obtained from the natural fall of 370 feet between the top of the Upper Rapids and the lower end of the Whirlpool Rapids.

At the present time, the combined capacities of the plants on the Canadian and American shores of the Niagara River, including DeCew Falls, are 1,194,000 hp and 590,000 hp, respectively, making a total of 1,784,000 hp. However, the great disparity between the two will be reduced once the Americans decide whether New York State, the United States Government, or private utilities shall undertake further development of the power potential of both the Niagara and the St. Lawrence rivers. A bill authorizing the latter to build stations there is now before Congress.

Canadians have traditionally been, and of course still are, very conscious of the value of water power, and at the end of 1952 the Dominion's hydro installations amounted to 14,305,880 hp, or 991 hp per thousand of her population (1951 census, 14,009,429). For purposes of comparison, it is a matter of record (*Mineral Resources of the World* published in 1952 by Prentice-Hall) that in 1948 Canada and the United States produced 87 billion and 50 billion kwh of hydroelectric energy, respectively. Assuming that the United States has 150 million inhabitants, the per capita figures are in the ratio of 6.5 to 1. With several major projects now under construction in the Dominion, even this high ratio will undoubtedly be measurably increased in the next few years.

Canada is hydro-conscious because suitable water-power sites are well distributed throughout the Dominion and also because present centers of population are far from economic sources of other forms of energy such as coal and other fuels. A good idea of the hydroelectric power available in the Dominion can be obtained from a recent report of the Department of Resources and Development, Ottawa, Ont., (Bulletin 2372, *Water-Power Resources of Canada*), which indicates that the country's presently recorded resources would permit the generation of nearly 66 million hp. Thus,

today's installed capacity represents only 22 percent of the total potential.

Sir Adam Beck Generating Station No. 2 is being financed by the Hydro-Electric Power Commission of Ontario, popularly known as Ontario-Hydro, a coöperative and publicly owned enterprise. The vigor and acumen of the Commission loom large in that 42 percent of the potential water-power resources of Ontario has been developed, as compared with 22 percent for the Dominion as a whole. And when the 1,200,000 hp of the present undertaking is put on the line the difference will be much greater.

Ontario-Hydro was formed in 1903 under provincial authority to investigate the distribution of power then produced almost entirely by private companies in the Niagara area. Coincidentally, with the completion of the deliberations in 1906, the Ontario Provincial Government, prompted largely by the advocacy of Sir Adam Beck and others, created the Hydro-Electric Power Commission of Ontario by an act of legislature. Sir Adam was appointed chairman and continued in that office until his death in 1925. His successors were The Hon. Charles A. Magrath, The Hon. Robert Cooke, Thomas Stewart Lyon, Dr. T. H. Hogg, and Robert H. Saunders, the present chairman.

At the start, the Commission was merely a distributor of energy bought from privately owned power plants in the Niagara district. But as its financial structure grew, it was able to undertake minor generating projects and acquire larger stations from private utilities. In 1917 the Ontario Power Company plant was purchased outright, and in 1922 that of the Toronto Niagara Power Company. Parallel developments took place throughout the province in the course of the years until Ontario-Hydro has become preëminent in the related fields of construction, operation, transmission and distribution.

Including energy bought under contract and sent out over its system, Ontario-Hydro's dependable peak capacity amounted to 2,597,200 hp in 1945, and six years later it reached 3,943,400 hp. By the end of 1956, with additions from both hydro and thermal stations now building, it will, it is estimated, approximate 5,807,600 hp, representing an increase of 124 percent in eleven years.

The founding and growth of Ontario-Hydro have been attended by a considerable amount of soul-searching in the province as to the merits of public versus private owernship. Canadians have a healthy appreciation of the tremendous amount of work to be done in the development of their big and promising land, and therefore are not too prone to seek bogeys in every mention of public ownership (at least where public utilities and certain other kindred services are concerned) so long as someone gets on with the job that needs to be done. On this count, Ontario-Hydro has justified itself and has shown exemplary initiative in anticipating and meeting the power demands of Ontario's 4,766,000 people and their industries. Incidentally, in its many ramifications, the Commission is one of the largest single employers of engineers in the Dominion.

Almost as soon as the Niagara's resources began to be harnessed about the turn of the century, it became apparent that agreements would have to be reached between the United States and Canada in order to preserve the spectacular beauty of the cataracts and to apportion fairly the water diverted for power generation. Over the years, the negotiations that have resulted in a succession of treaties have always been characterized by that spirit of friendly coöperation, understanding and mutual respect that obtains between the two countries and stands as a model for the world.

Under the Treaty of 1910, the maximum allotments were: Canada, 36,000 cfs; the United States, 20,000 cfs. The apparent discrepancy was due to the presence on the Canadian side of the American-owned Canadian Niagara Power Company which was producing current for consumption in the United States. During the Second World War emergency agreements were entered into by the two nations, raising the respective

CANAL WALL

The sheer rock face of one wall of the canal that will carry water 2¼ miles from the downstream ends of the tunnels to the powerhouse forebay. Note the drill marks showing near the top. Most of the canal will be of rectangular section, averaging 185 feet wide and 70 feet deep. It will be unlined, studies having convinced the engineers that the friction of the rock will not appreciably affect the flow.

quantities to 54,000 cfs and 32,500 cfs to meet the needs of vital defense plants on both sides of the International Boundary. Again, the reason for the disparity was as before.

The latest of the Niagara Diversion Treaties, that of 1950, was written first to protect the scenic beauty of the falls and gorge and then to permit using the maximum available water for power generation. Between the hours of 8 a.m. and 10 p.m. from April 1 to September 15 a minimum of 100,000 cfs must flow over the cliffs. This period is shortened by two hours from September 16 to October 31. All water in excess of that volume can be utilized for the development of electric energy. But during the nontourist season from November 1 to March 31 any flow exceeding 50,000 cfs can be used for that purpose except when it is necessary to flush ice out of the gorge below the falls. Under the treaty, half of the diversion will be available in Canada and half in the United States. The Dominion is allowed an additional 5000 cfs that the Commission diverts from the Hudson Bay drainage area.

The 1950 Treaty also stipulates that remedial works shall be constructed in the river above the falls to effect a more even distribution of the flow along the crest lines of the two cataracts. Not only will that requirement be satisfied upon completion of the job but erosion at the center of the Horseshoe Falls, now estimated at 2.3 feet per year, will be considerably reduced and many generations thus added to the life of the spectacle.

As soon as the 1950 Treaty was signed, Ontario-Hydro, hard-pressed by the demands of the province's rapidly expanding industry and rural electrification, made arrangements for an immediate start on the $300 million project that will result in placing on the line Sir Adam Beck Generating Station No. 2. Incidentally, the latter will be the fourteenth new power source provided by the Commission since 1945. It will ultimately contain twelve units of 100,000 hp each and bring the aggregate capacity of the stations on the Canadian side of the Niagara River to about 2,000,000 hp, allowing for an eventual reduction in output of the "Ontario" and "Toronto" powerhouses.

Work on the project was begun in January, 1951, and shaft sinking for excavating two parallel tunnels was undertaken the following July. No. 1 Tunnel was started in May, 1952, and is scheduled for completion in December of this year. Originally it was intended to finish the first tunnel before proceeding with the second one. But early in 1952 the Commission decided to begin its construction without delay and, as a consequence, No. 2 Tunnel will be completed a few months after the first one.

At normal water level, the greater part of the total drop of 326 feet in the 35 miles of the Niagara River system is concentrated in the 7-mile stretch from the head of the Upper Rapids to the Queenston end of the Whirlpool Rapids. The older plants, except that of the Ontario Power Company, were designed to utilize only the approximate head available at the Horseshoe Falls—its 162-foot cataract representing about half of the total drop throughout the system.

The success of the Sir Adam Beck Generating Station No. 1 has had much to do with the general concept of the present project, and a few notes on its creation and operation are therefore in order. Ontario-Hydro's first major undertaking in the field of power-plant construction, it was begun during World War I and placed in service in 1922. Together with certain additions made between 1922 and 1930, it has an installed capacity of 525,000 hp and is still one of the world's most efficient hydroelectric stations. At the time it was built it was also the largest. Together with its attendant works it was designed and constructed by the then young Commission's own staff of engineers, and this fact alone is indicative of the character of Ontario-Hydro and its achievements. As previously mentioned, the plant operates under a gross head of 315 feet between the intake at the mouth of the old Welland River to its site near Queenston, and is the first one to take advantage of the combined drop of the river's three principal sections. The desirability of this is proved by the fact that the station's generation factor is 22 kw/cfs,

PARTLY FINISHED TUNNEL

The tunnels are the largest of their length ever driven. They are being excavated 51 feet in diameter and will be lined with concrete 3 feet thick. This picture shows steel arch supports in place and curbs that bear rails for use of the drilling and concreting carriages. The finished section will be circular.

whereas that of the old "Toronto" plant is only 7 kw/cfs.

Water for Station No. 1 is taken from the Niagara River at Chippawa, and is conducted along the Commission's power canal shown on the accompanying general plan. The first 4¼ miles of the system was made by dredging and cutting the banks of the Welland River to a depth of 38 feet, with top and bottom widths of 307 feet and 185 feet, respectively. This stretch extends to a point about a mile north of Montrose, whence the water flows to the plant through an artificial canal cut in overburden and rock for a distance of 7½ miles. This section is 48 feet wide and in places as much as 75 feet deep. At the time of its construction, the canal, together with attendant works, represented an engineering feat of major proportions, involving as it did the excavation of 29,250,000 cubic yards of earth, 4,350,000 cubic yards of rock and the placing of 340,000 cubic yards of concrete.

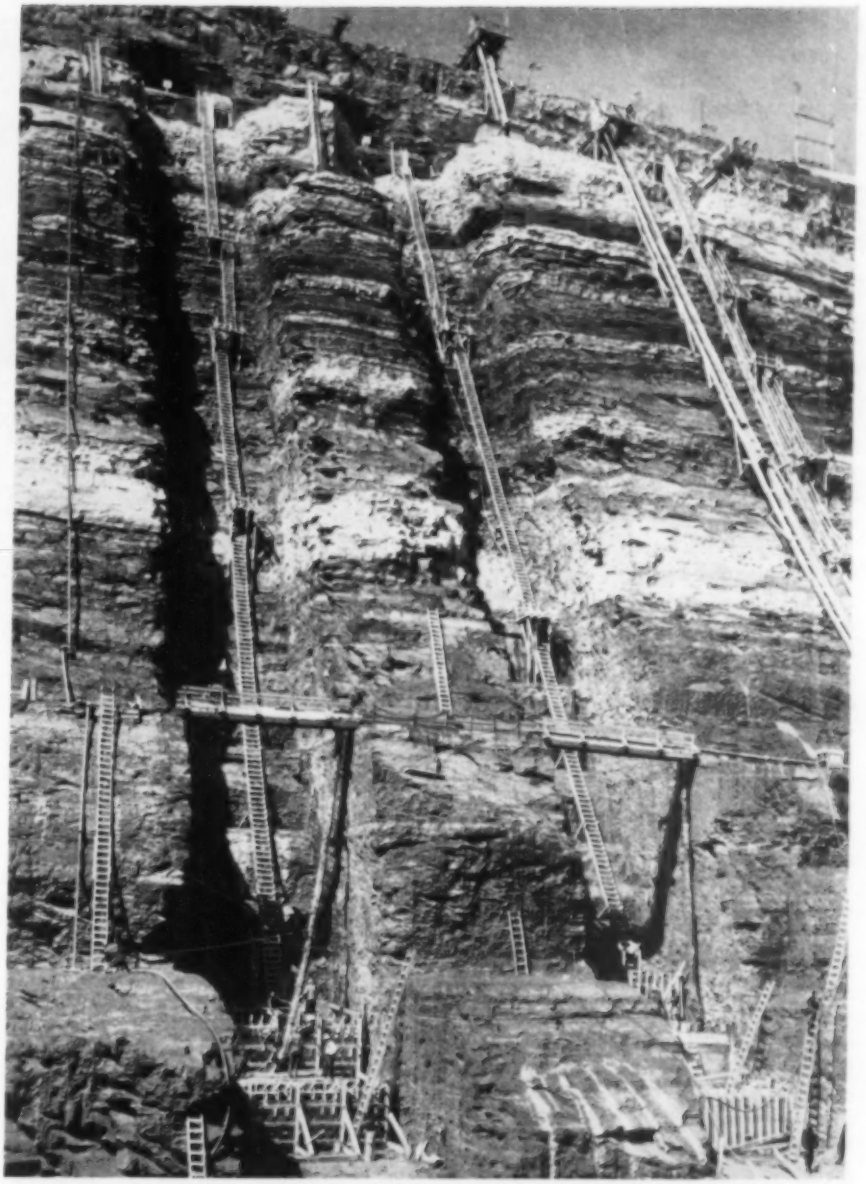
With the high generation factor of the Chippawa-Queenston stretch, there was virtually no question as to the waterway system for No. 2 Station, though the selection of the route and means was not so simple as in the days of World War I when the first Queenston plant was planned. During the intervening years the land traversed by the Chippawa-Queenston canal has become highly developed and is now urban and suburban in character, in marked contrast to its predominantly agricultural nature 40 years ago. After considering various schemes, the present arrangement of tunnels and canal to deliver 40,000 cfs was decided upon, and its adoption has entailed hardly any appropriation of highly developed land.

The intake site is situated about ¼ mile downstream from the Village of Chippawa, and the works there will consist of two submerged gathering tubes running parallel and 250 feet apart. Each will be about 500 feet long and will have an internal diameter approximately equal to that of a tunnel it will supply with water. The latter will enter the tubes through a series of slots located at intervals throughout their length. This type of intake was chosen primarily because tests showed it to be comparatively free of any tendency to admit floating ice, large floes of which pass from Lake Erie into and down the river system during the winter months. The installation also includes gates so that the tunnels may be isolated and unwatered for inspection and repair. This phase of the undertaking is being executed by Ontario-Hydro's own staff of project engineers which has gained considerable experience as well as an enviable reputation in this class of construction.

From the intake works or gathering tubes, the water will be conveyed through the tunnels for a distance of 5½ miles to emerge at a point just beyond the northern limits of the City of Niagara Falls, Canada. Each of these paralleling conduits, which are being driven 250 feet apart, is being excavated to a diameter of 51 feet and will have a finished inside diameter of 45 feet when the smooth concrete lining is in place. They are being advanced from five shafts spaced at intervals of 6225 feet, more or less, and situated halfway between the tunnel center lines so that both bores may be driven from a single set of shafts.

Tunnel No. 1, following the outer course around the bend of the Niagara River, will be 28,535 feet long and No. 2 27,300 feet, making a total of 55,835 feet or 10.6 miles. Their combined length will therefore be greater than that of any other bore of comparable diameter ever excavated, and represents an engineering job of major proportions. Allowing for reasonable overbreak, they entail the removal and disposal of some 4,000,000 cubic yards of rock, measured in place, and the lining will call for around a million cubic yards of concrete.

By way of contrast, the four diversion tunnels at Hoover Dam have an excavated diameter of 56 feet, but their aggregate length is only 16,000 feet. The Delaware Aqueduct in New York State is 85 miles long, but its greatest excavated diameter is 19 feet and it thus ranks favorably only in terms of earth and rock removal. Other important tunnels with which comparisons may be made are: Fort Peck in Montana, 25 by 25,294 feet; Tahtsa-Kemano, British Columbia, 25 feet by 10.1 miles; and



SLOTS FOR PENSTOCKS

Two of the twelve trenches for housing the penstocks through which water will drop approximately 295 feet to the turbines. Each 500-ton, steel conduit will be 19 feet in diameter, 492 feet long and will descend the cliff on an angle of 60 degrees.

Donje, Norway, 36 by 41 feet (horseshoe section) by 15,310 feet.

It will be noted from the accompanying plan and section that the deepest part of the twin bores is in the vicinity of Shaft 5 near the intake where the invert elevation is some 330 feet below surface level and that the shallowest is at Shaft 4 close to the discharge end where that elevation is about 200 feet underground. This variation is due to the underground geology of the area, and will be discussed more fully later. The intake and discharge ends are in the form of raises inclined 30° from the horizontal, and transition from the tunnel invert grade is accomplished through a vertical circle with a minimum radius of 225 feet. The same radius applies to horizontal curves wherever they occur.

As already indicated, tunnel driving is divided into five sections: Sections 1 and 2 in both bores are being excavated on a unit-price basis under contract with Rayner-Atlas Company, Ltd., a partnership set up for the duration of the project by two Canadian construction firms —George Rayner Construction Company, Toronto, and Atlas Construction Company, of Montreal. Contracts for sections 3, 4 and 5 were awarded to Perini-Walsh & Associates, similarly formed by B. Perini & Sons, Framingham, Mass., U.S.A.; Walsh Construction Company, New York; and Canadian-American Contractors. Sections 1 and 2 comprise 12,435 feet in Tunnel No. 1 and 12,080 feet in Tunnel No. 2; the corresponding combined footages in Sections 3, 4 and 5 are 16,100 and 15,220, respectively.

From the tunnels the water will flow into a canal 12,000 feet long and 185-200 feet wide (185 feet throughout most of its length). The average depth of the excavated cut will be 70 feet, of which 50 feet will be in rock, and the depth of the water carried will normally be around 28 feet. For a distance of 2200 feet from the tunnel outlets, the canal will be of trapezoidal section 500 feet wide at the top and 100 feet at the bottom to provide a channel across the buried St. David Gorge—an inter-Pleistocene course of the Niagara River. Throughout its perimeter, the trapezoid will be paved with concrete laid on a smooth-graded bed of riprap and crushed stone. The canal section entails the removal of more than 16,000,000 tons of earth and rock.

One of the interesting features of the open-cut design is a crossing at the point where it intersects an old canal some 16,000 feet downstream from the tunnel exit portals. Both are high-velocity streams and are at identical water and invert levels. The problem was how to make the crossing without undue loss of head through turbulence. In order to determine how best to meet this unique condition, a series of investigations was carried out with a working scale model of the two waterways and proved that a satisfactory interchange of waters between the two streams, with full maintenance of hydraulic characteristics, could be effected by offsetting the new canal some 45 feet at the downstream side of the intersection. This will cause some of the waters from the old channel to flow into the new one and vice versa.

A model was also put to profitable use in designing the forebay in that it showed that there would be two substantial dead spots of water in that basin if the preliminary plans on paper were followed. It has thus avoided removing some 250,000 cubic yards of rock. It has been estimated that the fairly extensive model studies made in working out details of several phases of the project have resulted in a saving of about $5,000,000.

The new powerhouse will be a steel-and-concrete building at the bottom of a 300-foot cliff and situated immediately upstream from Sir Adam Beck Generating Station No. 1. The structure will be 931 feet long, 63 feet wide and 60 feet high, and of the generating units five are scheduled to be put in service in 1954, six in 1955 and the remaining one in 1956. Each will have a capacity of 75,000 kw and its turbine will be supplied with water from the forebay through its own concrete-encased steel penstock 19 feet in finished inside diameter and laid in a slot excavated in the face of the hillside. After delivering its energy, the water will be discharged into the Niagara River at the foot of the Whirlpool Rapids and resume its course to Lake Ontario.

To erect the power plant it was necessary to cut a road down the flank of the cliff, a job that in itself was something of an engineering achievement. It has a length of 1¼ miles and was constructed at a cost of $600,000. With the exception of the tunnels, all excavating and erection, including the intake works, power canal and station, are being done by Ontario-Hydro.

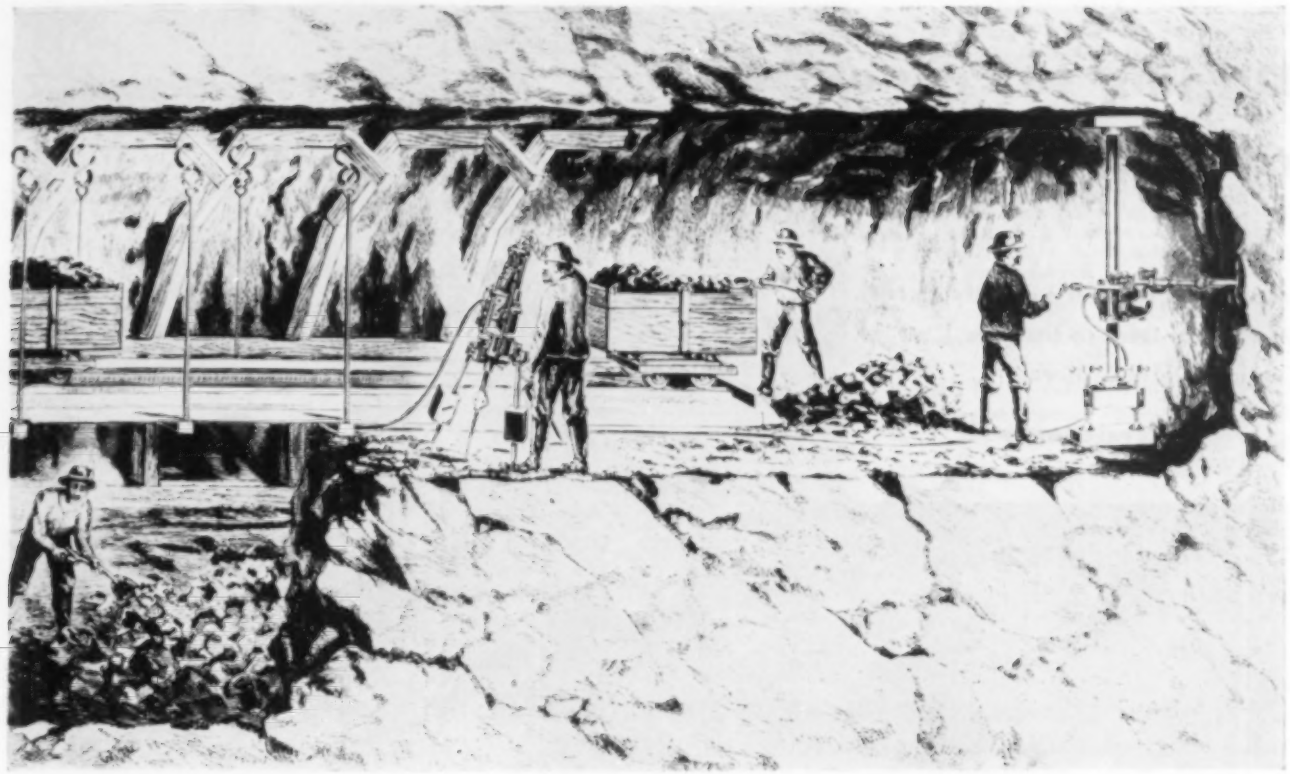
It is of interest to note that the unit cost of excavating on the undertaking as a whole is slightly lower than it was during the latter part of the work on No. 1 plant and shortly after World War I despite the fact that the hourly rate paid labor has increased greatly since then. This is of course attributable to the many improvements made in the past 30 years or so in the design and manufacture of equipment, in explosives and in engineering organization.

Spoil disposal presented a considerable problem, particularly in view of the built-up condition of the City of Niagara Falls and the Township of Stamford. By careful planning it was possible to provide for the purpose a total of about 640 acres situated at various strategic points. To reach these, some 25 miles of heavy-duty construction roads had to be built. Upon completion of the project, the dumps are to be suitably landscaped at Ontario-Hydro cost and all temporary buildings and structures are to be removed.

To avoid placing undue strain on existing municipal services, a great deal of planning had to be done to establish camps and other facilities to meet the needs of a temporary additional population of 7000. Included among these are a self-contained 30-bed hospital, water-distribution systems, sewage-disposal plants and the Commission's own security organization. On the engineering side, Ontario-Hydro has set up two large con-

COMING UP FOR AIR

The downstream end of No. 1 Tunnel where it slopes upward to meet the bed of the connecting canal.



EARLY NIAGARA TUNNEL

Tunnels are not new to Niagara, but the equipment and methods utilized in driving them have changed greatly since 1890 when a 7250-foot bore was excavated, as shown in this old print. Twenty-five Rand piston-type rock drills were used. Note the hanging platform that permitted advancing the top heading and bench simultaneously.

crete mixing plants: one near Shaft 5 and the other, larger one close to the source of supply of aggregate obtained in excavating the canal. The latter plant has a capacity of 180 cubic yards an hour.

A preliminary survey of the entire area entailed the sinking of approximately 16,840 diamond-drill holes, and as operations progressed and more detailed information about underground formations was required, the footage of exploratory holes was tripled. The rocks of the region were laid down in Ordovician and Silurian times and, in general, the strata dip gently to the south-southeast 28 feet to the mile, though diamond-drill intersections (cores) indicate local dips up to 60 feet per mile.

From arch to invert, the various members exposed in advancing the tunnel faces are: Reynales dolomite, 12 feet; Neagha shale, 6 feet; Thorold sandstone, 8 feet; and Grimsby sandstone, 25 feet. Except for minor variations as excavating progresses, the arches are maintained on the lower contact of the Irondequoit limestone of the Clinton formation, thus insuring a roof of the greatest possible competence and determining the vertical elevation of the tunnels and their invert grade of about 28 feet per mile upward in the direction of the eventual flow. This explains why the ends of the two tunnels are at different depths.

Coarsely crystalline in texture, the limestone is dense and relatively unjointed and its upper and lower contacts are clearly defined. The upper 15 feet of the Grimsby member is massive and slightly stratified; but with depth the sandstone becomes more stratified and there is an increasing incidence of shale parting submembers. Some of the latter have a tendency to squeeze or flow under pressure and caused minor difficulties in benching operations until the routine was altered, as will be described in the concluding installment of this article.

The presence of the St. David Gorge, mentioned previously, necessitates terminating the tunnels at a point short of its south bank and carrying the water across and thence to the powerhouse by canal. In inter-Pleistocene times the gorge was the channel of the Niagara River from the Whirlpool to what is now Lake Ontario and was cut by the St. David River (comparable to the Niagara). During the Pleistocene era the region was invaded by two distinct ice sheets separated in point of time by a relatively mild recessionary period. It was during the second or Wisconsin glacial period that the land surface was eroded, leaving a heavy mantle of till that filled the gorge.

Because of the resultant filling and blocking of other outlets to the North, drainage for a time was southward to the Mississippi system, the rock contours showing that a broad, shallow channel extended southward from the Niagara in the vicinity of the intake works above the Upper Rapids. As the Wisconsin sheet retreated farther northward, and as the waters in the basin dropped, new outlets to the North were formed and, in time, one of them became the present Niagara Gorge from the Whirlpool to Queenston.

On the surface, the St. David Gorge is known to be some 2000 feet wide, but its depth is a matter of conjecture. It is filled with heterogeneous unconsolidated glacial till relatively poorly drained. Like in the case of the No. 1 power project, the only economic choice was a surface canal across the gorge, with enough space between the circular tunnels and the trapezoidal section of the open waterway for adequate hydraulic transition.

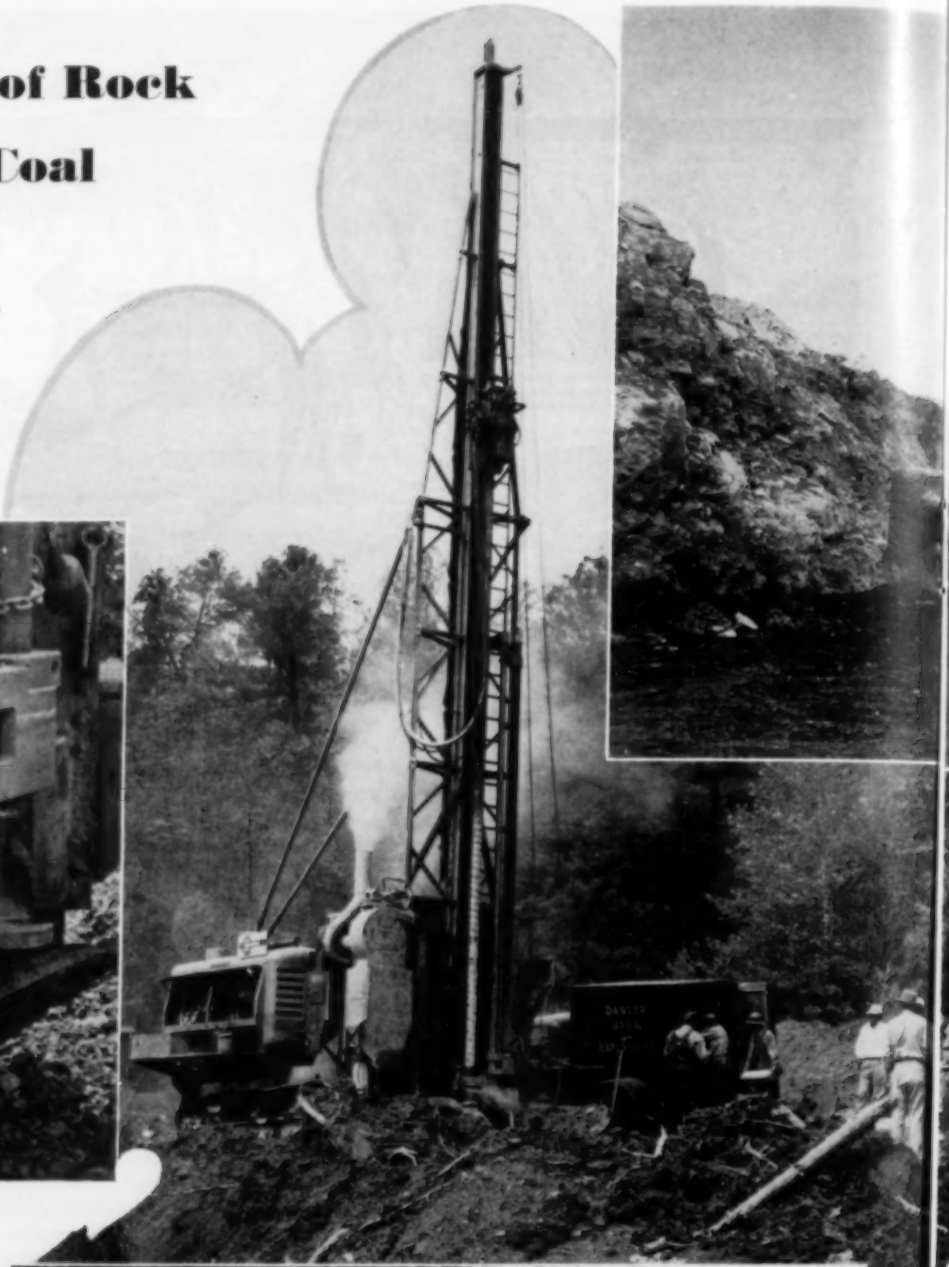
Except for the trapezoidal section, the rectangular or main stretch of the canal will be unpaved and unlined, the lower 50 feet of its 70-foot depth being in massive, coarse- to medium-grained crystalline Gasport limestone, a member of the Lockport formation that also supplies the project with concrete aggregate of excellent grade. The invert is in contact with DeCew dolomite which offers the excavators an excellent parting plane with a smooth surface and does not have to be paved.

The concluding installment will appear next month.

Digging 40 Feet of Rock to Get 2 Feet of Coal

Alabama Producer Literally Turns Mountain Over to Uncover Thin Seam of Mineral

Ted Slager



QUARRYMASTER AT WORK

Entirely air operated, this efficient heavy-duty drilling machine with a 50-foot tower (above right) puts down 40-foot holes through shale and sandstone at the rate of 80 to 100 feet per hour. The original Quarrymaster was a percussion drilling outfit, whereas this one literally bores its way through the rock by turning a typical oil-field type of cone bit, shown close up above.

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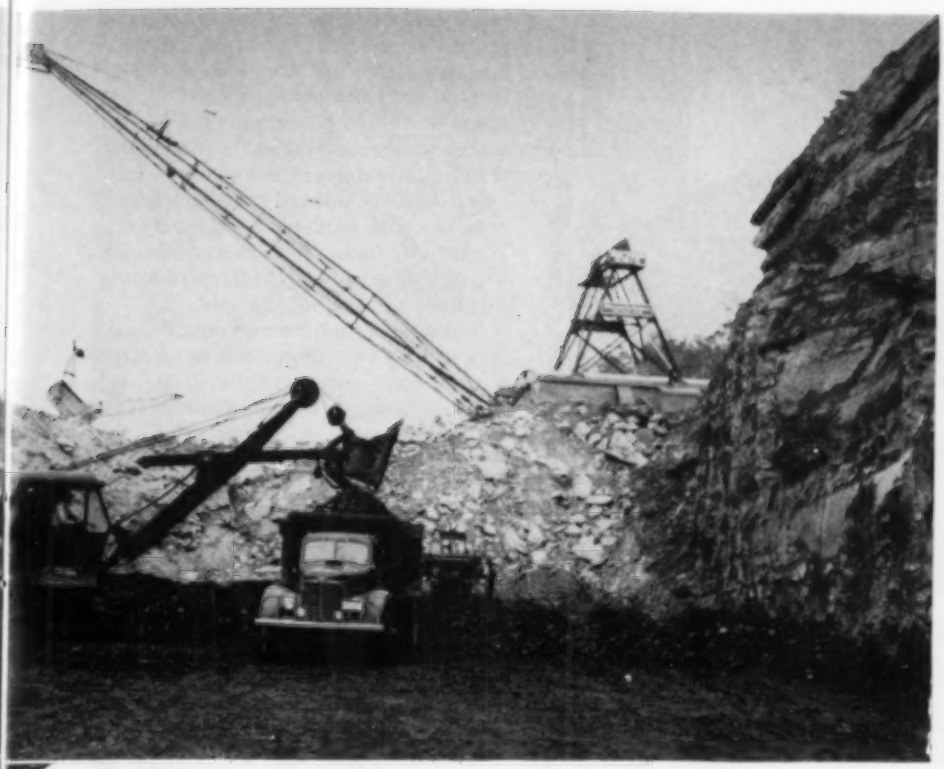
CLEARING THE WAY

As the first step in the mining sequence, bulldozers clear away trees and brush and smooth the surface to facilitate subsequent drilling and excavating operations.



HARD-WON PRIZE

The picture at the left pretty much epitomizes the multiple-step excavating process. In the background, a Bucyrus-Erie walking dragline with a 165-foot boom and a 11-cubic-yard bucket is stripping overburden, shattered by drilling and blasting, from a 2-foot coal seam. In the middle-ground, just right of the coal truck, is an International high-lift truck removing the final few inches of earth and rock. In the foreground, coal is being loaded by a 1-yard power shovel.

OPERATING HEADS

Reed Jackson, left, superintendent of the job, and Newton H. DeBardeleben, president of the coal company that bears his family name.

SELDOM has Mother Nature been as kind to man as she has in an area of approximately 50 square miles around Birmingham, Ala. There she has deposited huge quantities of the three main ingredients needed by the steelmaker—hematite ore, coal to make the necessary coke, and limestone to serve as flux. In fact, it is said to be the only place in the world where these substances are found together in such abundance.

Coal underlies about 40 percent of the northern half of the state, and the total available resources are estimated to be 66,711,378,260 short tons, or enough to last 7500 years at the present rate of production. The principal iron ore, red hematite, lies chiefly in the region around Birmingham, and the richest deposit is located in a 14-mile strip between that city and Bessemer, Ala. Four large steel companies—Tennessee Coal, Iron & Railroad Company, Republic Steel Corporation, Woodward Iron Company and Sloss-Sheffield Steel & Iron Company—have taken advantage of the proximity of iron and coal and are mining both to supply their blast furnaces with those raw materials.

However, our story has to do with coal, and it would not be fair to tell it without introducing the pioneer De Bardeleben, Henry F., who played so important a part in the development of the Birmingham district and whose name is synonymous with Alabama's coal industry. (Originally, during America's revolutionary period, the name was Von Bardeleben, but as the wife of the early Von Bardeleben was of French ancestry he decided to substitute "De" for "Von.")

It all began in 1872 when Henry F. left his home in Prattville, Ala., to look for his fortune in the hills around Birmingham. He discovered and developed the state's original coking-coal seam, which he named the Pratt Seam in honor of his wife's family. The company he founded became the Tennessee Coal, Iron & Railroad Company in 1892. For years DeBardeleben's son Henry T. followed in his father's footsteps in the coal, iron and steel business and in 1912 organized the DeBardeleben Coal Company with the opening of the Sipsey Mine. In 1923 that concern merged with the Empire and Corona Coal companies to form the DeBardeleben Coal Corporation, which Henry T. headed and expanded for 36 years. Today one of the latter's sons, named Henry F. for his illustrious grandfather, is chairman of the board and another son, Newton H., is president.

The DeBardeleben's are literally turning over a mountain in their coal-stripping operations 34 miles north of Birmingham and are proving that it is possible with modern machinery and methods economically to strip overburden that other producers considered too expensive to tackle. The 80 miles or so of outcrop already explored does not lie in a straight line, but meanders through the mountainous countryside. The bed of coal is fairly flat and pitches 1° to the southwest. An average of 2 feet thick, the coal is of exceptionally high grade, having an ash content of only 2 percent. Some of it is processed in the company's own coking plant, but the bulk is sold in graded sizes to retail, commercial and industrial outlets. It is estimated that there is enough coal mapped out to keep the corporation busy for the next sixteen years mining about 5 miles of outcrop annually. The reserves represent a life of about 40 years.

Practically all the so-called easy coal—that which lies 10 to 20 feet under shallow overburden in the valleys—has long since been recovered by strippers. The early-day miners used auger drills to bore horizontal blast holes in the fairly soft-rock cover, but neither augers nor churn drills could profitably negotiate overburden exceeding 20 feet.

The 2-foot seam now being mined and known as the Black Creek Seam will in places be cleared of rock up to 70 feet in depth. This work is being done in stages or benches. The one being drilled and blasted at present is 85 feet wide, 500 feet long and approximately 40 feet deep. The amount of rock and overburden removed per ton of coal is 21 cubic yards, which is considered to be the economic limit under prevailing conditions.

The cycle of operations is as follows: First a caterpillar-dozer prepares a road or bench on a hillside by pushing earth around until there is a flat surface on which the big self-propelled drilling rig utilized can maneuver. It is an Ingersoll-Rand Quarrymaster, a self-contained machine equipped with a rotary drilling

AFTER THE COAL HAS BEEN EXTRACTED

A 50-foot wall left in one area after the coal strippers had passed by. The 2-foot seam of coal is hardly discernible at the bottom. A narrow band of low-grade fuel, too poor to warrant mining, may be seen about halfway up.

head operated by an air motor and using a Hughes Tri-cone or roller bit 7⅜ inches in diameter. The drill tower, which is 50 feet high, handles 40-foot steels. For the most part the drill is putting down 40-foot holes, each in one operation with no steel changes, bottoming them within a foot or two of the coal seam. For the few holes that are deeper, one steel change is required.

The blast holes are drilled in rows 16 feet apart and are on 18-foot centers. They are loaded with explosives in cylindrical cartridges from 5½ to 7 inches in diameter and 24 inches long, the number and spacing depending upon the respective amounts and distribution of sandstone and shale to be broken. Firing is done with delay primers. Powder consumption ranges from 0.3 to 0.4 pound per cubic yard of rock.

With the 7⅜-inch bit, the Quarrymaster drills from 80 to 100 feet an hour. The rock is about half shale and half sandstone. Generally, a thin layer of shale is found directly over the coal, but occasionally sandstone is encountered there. The rotating bit penetrates the formation under sufficient pressure to crush the rock into sizable chips which, together with the fines, are blown out of the hole to the surface by a continuous stream of air flowing down through the hollow drill steel. There is an efficient dust collector on the rig in which the cuttings are stored in two hoppers of generous size. The coarse rock fragments are used as stemming after blasting powder has been lowered into the hole.

The Quarrymaster is equipped with two compressors which supply air to operate the drill, clean the hole, serve the dust collector and drive the air motor that propels the machine. After the rig is spotted for drilling, three hydraulic jacks quickly bring it to a level, which is done only as a convenience where ground is uneven because blast holes can be put down at any angle at which the machine may be standing. A comfortable cab is provided to protect the operator from the heat of the sun or winter's cold.

Following drilling, a Bucyrus-Erie walking dragline moves in on the job. It has an 11-cubic-yard bucket suspended from a 165-foot boom and handles 10,000 cubic yards of material a day. As it travels along, it clears away the shattered rock almost down to the coal seam and casts it to one side. The work is finished by a TD-14 International high-lift truck which, because of the flat nature of the bed, removes the remaining material, leaving a clean coal face exposed. Then, without further blasting, a small 1-yard steam shovel scoops the coal directly into trucks for transportation to the nearby washing, cleaning and sizing plant which was recently completed and which is said to be the most modern one in the South. It generally takes five days to drill out a bench, five days to strip off the rock and five days to take out the coal.

The washery requires about 2300 gallons of water a minute, and as no large natural streams are nearby, it is used over and over again for cleaning coal. The company has converted a large abandoned strip-mine pit fed by springs and drainage into an impounding reservoir. The supply from this source serves as make-up water and is delivered through a 6-inch pipe line, 8680 feet long, into a storage basin at the processing plant. The dirty water from the latter flows into a settling basin and is pumped back into the washery reservoir.

In addition to the extensive mining operations described, the corporation also owns a large coke-and-coal chemicals plant at Holt., Ala.—enterprises all laid on the foundation built by the pioneering Henry F. DeBardeleben. The caliber of that picturesque man is best expressed in his own words quoted by Ethel Armes in her book on *The Story of Coal and Iron in Alabama*. "I'd rather be out in the woods on the back of a fox-trotting mule with a good seam of coal at my feet than be President of the United States. There's nothing like taking a piece of land, all rock and woods—ground not fit to feed a goat on—and turning it into a settlement of men and women; making pay rolls; bringing the railroads in; starting things to going . . . . Nothing like boring a hillside through and turning over a mountain."

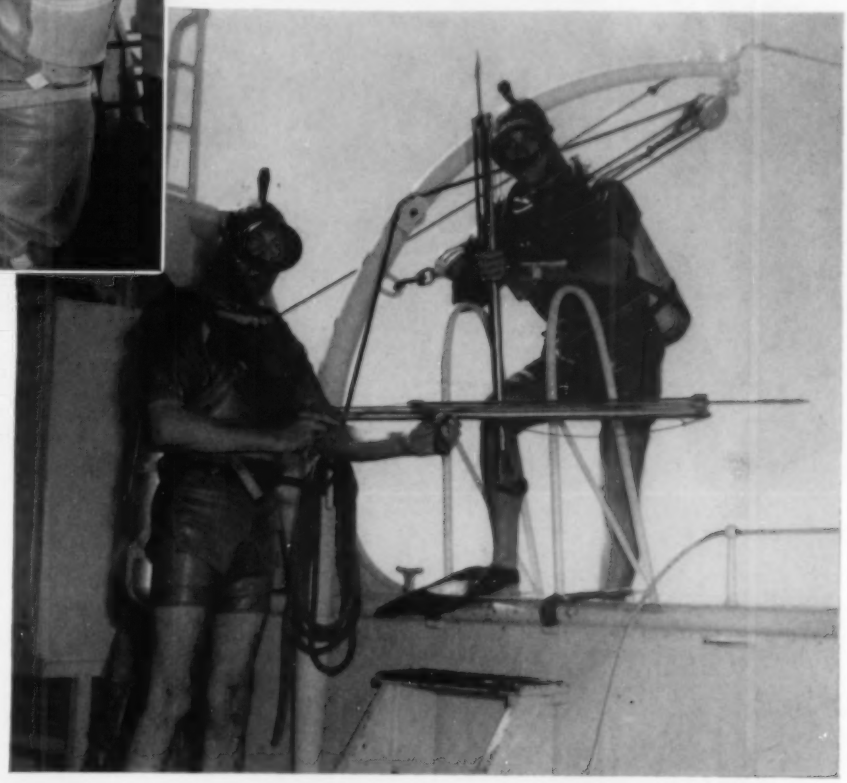
COAL-CLEANING PLANT

The strip-mined coal is trucked to this washery for cleaning and sizing, then shipped to market. The refuse is conveyed to the disposal area in the rear.

Compressed Air Under the Waves

The Aqualung Is Opening Up a Strange New Underwater World to Mankind

Robert J. Nemmers



INVENTOR AND MANUFACTURER

Capt. J. Y. Cousteau, originator of the submerging aid, is shown in the upper picture being helped into an air-insulated cold-water diving suit by Rene Bussoz who heads the U. S. Divers Company, American licensee for manufacturing the Aqualung. Bussoz and the unidentified man are wearing short American-made suits. In the lower picture, Bussoz and Paul Arnold are ready to go over the side of the "Velero IV" on a hunting expedition off Palos Verdes, Calif.

THERE is another world close to ours—a world of fantastic shapes and proportions, of brilliant colors and strange creatures. It is made up of the mighty seas that encompass three-fourths of the earth's surface. Far back in the memory of man lie dreams of the conquest of these challenging bodies of water. Man has accepted the challenges as best he could. Since the dawn of recorded history, and probably before, he has looked to the seas as a source of food. He has sailed upon the surface of the oceans, using them as highways to distant lands. Today he is well on his way to reclaiming some of the minerals washed into the seas through countless years of erosion.

Yet almost every man nursed a strong desire in his youth when he frolicked in the "ol' swimmin' hole," whether it was a lake, an ocean or a dammed-up creek. That wish is still being voiced by boys when they ask one another, "Wouldn't ya like to be able to swim like a fish and breathe underwater?" Today, a group born of these aspirations—*pisces homo sapiens*, menfish—has invaded the seas. Although that classification will probably never be accepted by an anthropologist, man today swims beneath the waves unencumbered by a heavy diving suit, helmet, shoes and air hoses extending to the surface. He is able to move freely to a depth of only around 130 feet right now, and is limited to about two hours' submersion, but within that realm he is undisputed master. Furthermore, this is not reserved for the classical he-man type; even women and children can swim and play and work there. This is a tribute to the safety and simplicity of the Aqualung, the mechanism by which man has answered one of the sea's challenges.

The Aqualunger is an odd-looking creature. Clad from head to toe in a close-fitting rubber garment, with the face obscured by an oval eye shield and an ungainly rubber "gill" from which two flexible spiral-wound hoses extend to a small regulator and tank assembly strapped on his back, he looks more like a man from Mars than from the Earth. Out of water he is graceless and slow on finlike feet. Underwater he glides and flits about like a bird; indeed, he is nearly weightless because of the buoyancy of the water. Behind him as he swims, bursts of bubbles in steady measured rhythm issue from the air regulator.

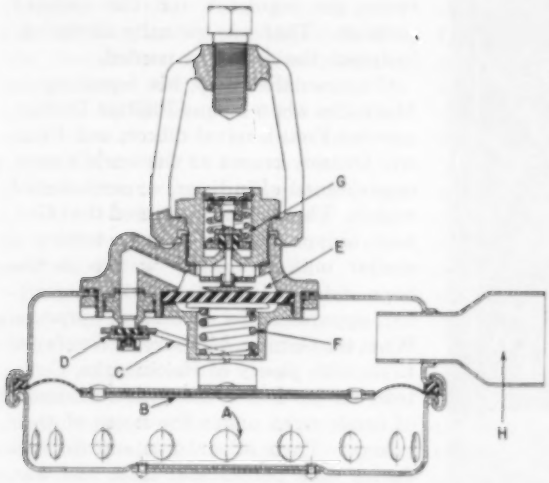
An ingenious contrivance, the regulator is the heart of the Aqualung system of diving. It efficiently reduces air pressure of more than 2000 psi to ambient pressure, regardless of what the latter may be, and then meters the air to the lungs of the diver as he demands or inhales it. An accompanying drawing shows the device in detail. None of the air in the tank or tanks, each of which holds 70 cubic feet of free air, is wasted. Built into the mechanism is a constrictor that warns the diver when his air supply is running out by suddenly making it hard for him to breathe. When this happens he knows that he has plenty of time to return safely to the surface if he starts to ascend immediately.

Aqualungs are now utilized the world over. Sportsmen armed with arbaletes, a crossbow that throws a spear, go deep-sea hunting with them, and men, women and youngsters find this unique pastime

MARINE HUNTERS

Outfitted in a skullcap and full-length rubber suit to ward off the chill of cold water, an Aqualung diver is pictured at the upper left about to descend in quest of swimming game. Under his left arm is an arbalete, a modern version of the crossbow, that throws arrowlike steel shafts. Lead weights around the man's waist will take him down quickly. The picture at the left shows A. F. Vander Kogel, diving specialist for the New York sporting goods firm of Abercrombie & Fitch, being hauled to the surface with a 150-pound member of the grouper family that he bagged with the carbon dioxide-powered spear gun in his right hand. In the other view is a diver with a 9-foot tiger shark that had to be attacked with five spears before succumbing.

PHOTOS BY E. L. FISHER AND SUBMARINE STUDIOS, MIAMI



HOW REGULATOR WORKS

Because it unfailingly supplies vital air to the diver, the demand regulator (above) is called the heart of the Aqualung. Water entering the base through holes "A" acts against diaphragm "B," which forms the bottom wall of the lower chamber. Movement of the diaphragm actuates valve "D" through lever arrangement "C," causing air to bleed from the upper chamber "E" into the lower one until the sea pressure is equalized. The pressure in the lower chamber, in combination with the spring "F," then acts to halt the flow of air from the diver's tank through valve "G." When the diver's breathing removes air from the lower chamber through port "H," the cycle repeats itself and is capable of matching the fastest breathing rate. Air exhausted from the diver's lungs is discharged into the water through a valve just below diaphragm "B." Diaphragm and spring-loading devices are so calibrated that the mechanism works on a pressure differential of only 2 to 5 psi, and this is readily produced by the lungs.

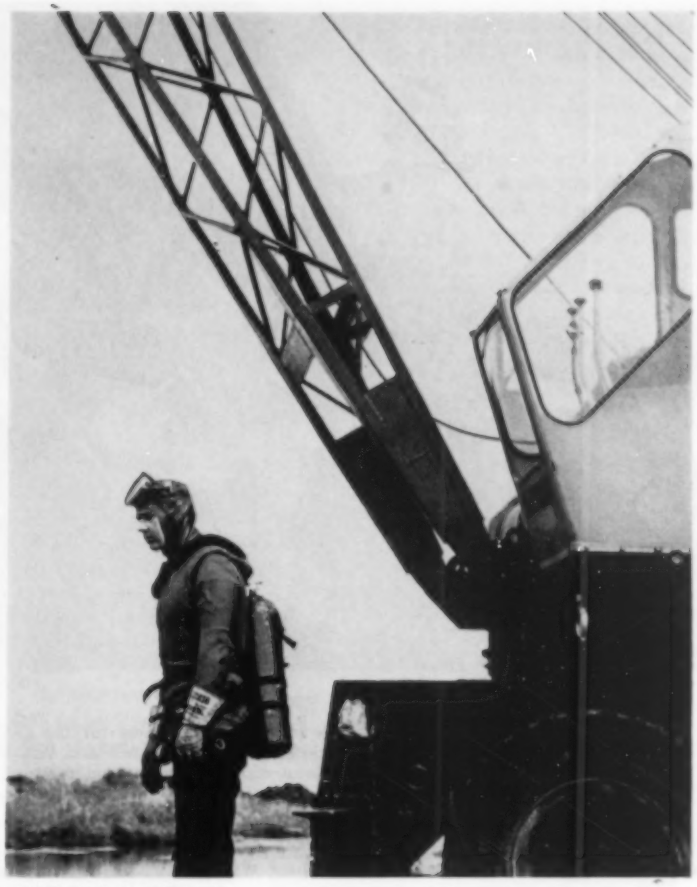


PHOTO BY E. L. FISHER

AQUALUNG SALVOR

C. F. Diercksmeier of Aqualung, Inc., shown while working on the recovery of a 17-ton load of reinforcing steel that was dumped into a canal by a trailer truck that went out of control.

fascinating. Scientists have adopted the equipment as a means of observation and research, and even the most unathletic of them can use the Aqualung with ease and gain first-hand knowledge of undersea conditions for which they previously had to rely upon the untrained eyes of others. Today the outfit is making it possible to add quantities of material to the world's book of facts about submarine creatures and plants. Underwater films of a scientific nature have so enthralled the layman that many of them have become box-office successes.

Most of the Aqualung's industrial applications are of the regulation diving-dress class and are performed more easily and cheaply because the diver is not hampered by heavy clothing and long lines. Off the Cape Verde Islands near the coast of Africa the Shell Oil Company of Portugal, Ltd., laid a submarine pipe line out from shore for a distance of 3300 feet to speed tanker discharge and turn-around at that important bunkering port. All the underwater operations were performed by a French diver and two local assistants using Aqualung equipment. The latter is definitely superior to the familiar rubber outfit in searching for small objects on the floor of the ocean. The leaden boots the helmet diver wears muddy the waters as he shuffles along, thus obscuring the view. The free-swimming Aqualunger, on the other hand, can glide along with his nose within a foot of the bottom if necessary without disturbing it.

The Aqualung represents the cumulative ideas and experiences of centuries. Many old manuscripts tell of crude attempts at constructing diving apparatus, and in one is a drawing of a man underwater breathing by aid of a bellowslike arrangement made of goatskin. Goggles enabling the wearer to see submerged have been known for hundreds of years. However, the development of feasible equipment had to await the day of reliable compressors and safe rubber hose.

The conventional method of delivering air to a diver through a long rubber hose obviously limits his working radius. In addition, he is entirely dependent upon a power supply that might fail without warning. Should that happen, his chances of reaching the surface without aid would be remote, even in shallow water, because of the weight of his suit. More than three-fourths of the air compressed for his consumption is wasted — bubbling uselessly from the exhaust valve on his helmet. All things considered, the Aqualung has an advantage over the helmet-type gear because it permits the wearer to swim like a fish with no encumbering lines that are always in danger of fouling.

During the mid-1930's, individuals seeking amusement, excitement and sometimes danger took up the age-old sport of skindiving. Those venturesome men gained fame along the coast of the blue Mediterranean Sea for their underwater exploits. Wearing no breathing apparatus and holding their breath for as long as three minutes, they hunted the depths with slingshots that threw spears at creatures which provided 80-pound fillets. Having caught glimpses of the submarine wonderland, they longed to spend more time there than their lightninglike dives permitted.

One of the first inventors who tried to make this possible was a Frenchman, Le Prieur, who slung across his chest a tank of compressed air and ran a hose from it to a rubber mouthpiece. He regulated the flow of air to his lungs by an interposed hand valve. At the best, this was a makeshift, for it was necessary to readjust the valve every foot he descended or rose. Consequently he spent more time providing himself with air at the proper pressure than swimming or looking around. Besides, at least half of the limited air supply was wasted in the process of adjustment.

The Le Prieur lung, however, did whet the appetites of others for a more work-

PHOTO BY JULIUS DOWN

THEY SAY IT'S FUN

Among the growing number of Aqualungers who dive for the thrill of it are Dorothy and Earl Warren, Jr., (right) children of Governor and Mrs. Earl Warren of California. They are shown with an unidentified companion ready for a trip into Neptune's domain.

able mechanism, and that brought about the development of oxygen apparatus modeled after the respirators used in gaseous mines and in fighting fires. Those units were self-contained and purified the air exhaled by the diver by passing it through soda lime which removed the carbon dioxide so the oxygen could be recycled. They provided a real opportunity for observation and sport while swimming beneath the surface. But they had one serious drawback. At depths below 45 feet the diver suddenly had convulsions and blacked out because of the extremely high concentration of oxygen in the bloodstream.

Then in 1942, two French scientists, Captain* J. Y. Cousteau of the navy and Emile Gagnan, produced a regulator that furnished air as required and that later became the main element of the Aqualung diving system. Cousteau was working with the Free French Security Forces at the time and functioned under the guise of a producer of scientific movies, while Gagnan was working on a method by which natural or manufactured gases could be substituted for gasoline in motor vehicles. The demand regulator was based on one the latter had conceived for the gas-burning internal-combustion engine.

The first regulator was tested outside of Paris in the winter of 1942-43 and was found to operate perfectly when the swimmer was in a horizontal position. However, when his head was down it was nearly impossible for him to breathe, and when his head was up the air rushed wastefully from the exhaust valve. Investigation proved that the exhaust was either higher or lower than the intake under those conditions, and though that resulted in a difference in water pressure of only 6 inches it was the cause of the trouble. It was corrected by placing the exhaust valve within an inch of the diaphragm that maintains a balance between the regulator and the ambient pressure. That was virtually all the adjustment the regulator needed.

Cousteau then took his Aqualung to Marseilles where he and Phillipe Tailliez, another French naval officer, and Frederic Dumas, known as the world's most experienced skindiver, experimented with it. There they discovered that German occupation forces were testing a similar unit in nearby waters in the hope of developing a free-swimming diving apparatus for military purposes. What the German Ministry of War failed to do with plenty of Reichmarks, Cousteau and his friends did with a minimum of funds right under the noses of their enemy. Their adventures and findings during this period and after the war, when they formed an underwater research group as an arm of the French Navy, are described in a fascinating book, *The Silent World*, by Cousteau and Dumas.

But before menfish could invade the sea with impunity, many problems had to be solved by compiling empirical data based on hundreds of dives by Cousteau and his friends. One of the first was how to keep warm while underwater. This had bothered them even before the advent of the Aqualung, for the chilling sea drained their energies. So they developed a lightweight rubber suit that is worn over woolen undergarments and that offers indefinite protection in the coldest waters. It comes without arm and leg coverings for waters above 55°F.

Another problem that had to be answered was the safe depth limit of the apparatus, and that could be determined only by dangerous experiments. Maurice

WIDE WORLD PHOTO

CIVIL AIR-PATROL FROGMEN

The Navy's vaunted Frogmen, whose exploits have been recorded in a popular motion picture, wear Aqualung suits. The diving aid has also been adopted by Civil Air Patrol forces. Members of the Salem, N. H., wing are shown here being trained to look for lost objects in the water, sunken planes and persons who have lost their lives by drowning.

*The equivalent United States naval rank is commander.

Fargues, an early diving companion of the Cousteau group, descended to 396 feet, deeper than anyone breathing unmixed air has ever gone, and wrote his name in indelible pencil on a white marker board at that level to testify to his achievement. (To measure the depth of each dive, a series of small marker boards was fastened at 5-meter (16.5-foot) intervals to a heavy shot line suspended from the surface craft).

Unfortunately, Fargues never survived that experience because he was a victim of another danger—nitrogen narcosis or rapture of the deep. This affliction is described as a drunken feeling of superiority over the sea and may cause a diver to do such a foolhardy thing as tear off his mouthpiece and offer it to a passing fish. Nitrogen narcosis is believed to be attributable to supersaturation of the body tissues with nitrogen and affects the central nervous system. It occurs at approximately 210 feet and is in no way related to the bends or caisson disease. It is believed that a mixture of oxygen and helium rather than the normal atmospheric mixture of nitrogen and oxygen might lessen or negate the effect.

As a result of the courageous explorations of Cousteau and his associates and others it has been possible to establish data governing depths at which Aqualung equipment can be safely utilized. In waters 130 feet deep, professionals can do hard work and even amateurs can swim without risk. Between 130 and 210 feet, skilled divers can perform light tasks and observational duties. But the realm between 210 to 300 feet can be explored with reasonable safety only by those highly trained, while that below 300 feet is so dangerous that invasion is believed to be flirting with death.

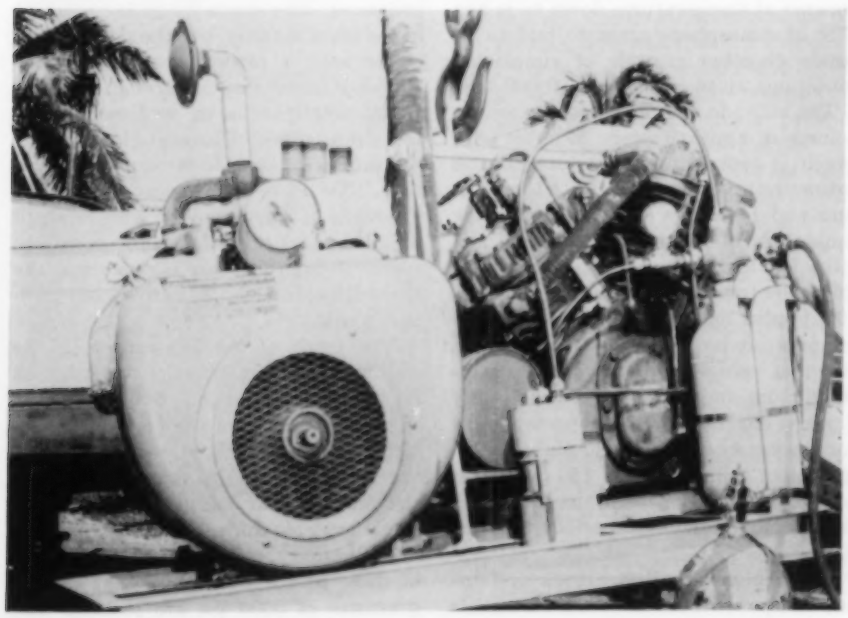
One of the afflictions to which the amateur is exposed is the bends. This "disease" attacks a diver when he remains under high pressure long enough for the nitrogen in the air he breathes to go into solution in his blood and to permeate his body. If he returns to the surface suddenly, the nitrogen in his body fluids and tissues expands, it literally froths, and the little bubbles may cause severe muscular cramps, paralysis and even death. Fortunately, this risk can be easily guarded against by surfacing in stages, pausing intermittently to allow the nitrogen to leave via the lungs while the body is still under partial pressure.

Aqualungers have set up decompression tables which, if followed, insure a safe swim and absence of the bends. For example, a diver working at a depth of 100 feet for a period of 25 minutes does not have to undergo decompression other than that brought about by rising slowly to the surface. However, should he remain there for 75 minutes, then he must pause at the 20-foot level for 27 minutes and at the 10-foot level for 21, making a total decompression period of 48 minutes. By following these rules, an Aqualunger—any diver, in fact—enjoys safety; by violating them, he invites disaster.

The future of the Aqualung seems bright. The U. S. Divers Company, the United States manufacturing licensee, lists among its users the United States, French and British navies; the universities of California, Washington, Wisconsin, Stanford and Southern California; as well as the Pacific Oceanic Fishery Investigations, the Fish and Wildlife Service, the U. S. Bureau of Reclamation, the Scripps Institute, the American Red Cross, several maritime organizations and thousands of sportsmen. Perhaps one reason for its popularity is the fact that it is relatively cheap—the purchase price of a de luxe lung and accessories, including hunting equipment, being less than $500. Upkeep and operation, too, are inexpensive.

However, there is the matter of compressed air at 2000 psi. That does seem to pose something of a problem for the individual who wants to go Aqualunging just for the fun of it. It has been suggested that these enthusiasts form clubs and prorate the cost of a machine among the members. For industrial uses, where high-pressure compressors are not available, the U. S. Divers Company is also offering a demand regulator known as a Hookah that permits connecting the Aqualung to a 150-psi machine by hose lines. While the latter do restrict the movement of a diver, still there are many commercial fields in which he can, nevertheless, perform valuable services.

Forecasts of possible uses for the Aqualung sound a little like fiction, yet man is turning more and more to the sea as a source of food and energy. It may well be that the deep-sea diving rig of the future will be modeled upon the Aqualung. It is also possible that one day we will see regiments of men working and playing beneath the waves. Whatever the final applications, it is certain that one more useful tool has been added to our stock and that it will help us to know more about the world in which we live.



AIR-CHARGING FACILITIES

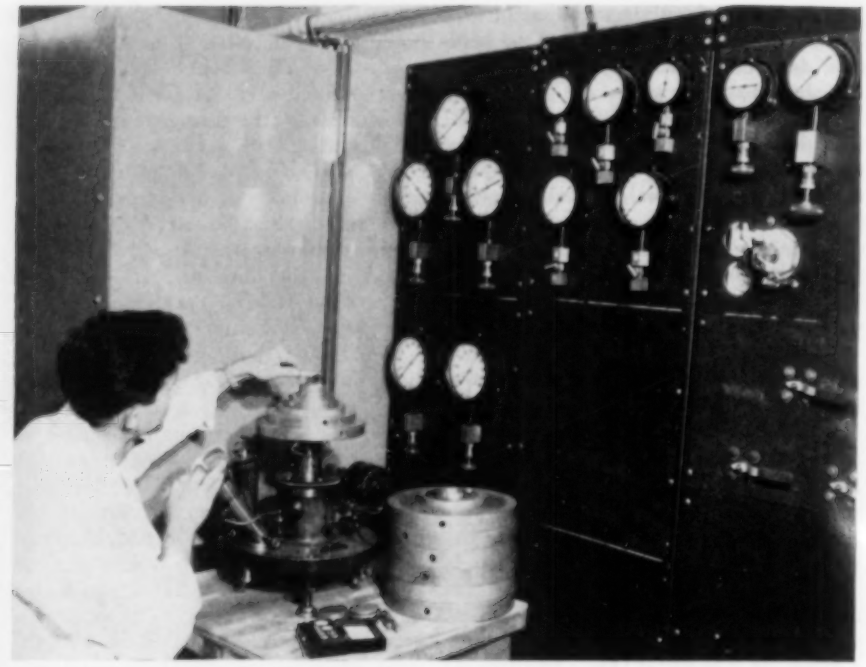
Pictured at the left is an Ingersoll-Rand compressor that delivers air at 2000 psi pressure for charging Aqualung cylinders. It is used by Aqualung, Inc., in Florida. The hook at the top is in a ring by which the machine is lifted aboard a ship or onto a truck for service away from the base. The other view shows an Aqualung's air cylinder being filled while submerged in a can of water that cools it so as to condense any moisture that may remain in the air after it has passed through a moisture trap and a spiral aftercooler on its way from the tall vertical storage reservoir.

Pneumatics in the Sky

Bureau of Standards Seeks Data on Uses of Air Power in Aviation

RECORDING PRESSURES

Rapidly changing air pressures are recorded by focusing a high-speed camera on a cathode-ray oscilloscope.



CALIBRATING GAUGES

Pressure acting on the gauges at the upper right is balanced against the pull of gravity on a group of weights supported by the piston of a precision dead-weight gauge on the table.

RECENT trends towards high-altitude flight and more efficient utilization of weight and space in aircraft have led to a much wider application of pneumatic systems for the purpose of performing such high-speed operations as extending and retracting the landing gear, ejecting the emergency canopy or seat, gun charging and rocket ejection.

Although compressed air has been used for many years, air-borne pneumatics is still in an early stage of development. In view of the high actuation speeds and operating pressures now being considered, a comprehensive program of research and evaluation is needed. To meet this requirement, a program for the study of high-pressure pneumatics has been established by the National Bureau of Standards at the request and with the coöperation of the Airborne Equipment Division of the Navy's Bureau of Aeronautics. Although primarily directed towards the needs of military aviation, the efforts of the NBS pneumatics laboratory should find wide application in the aircraft industry as a whole and in other fields of high-pressure technology.

Under the direction of Dr. Milton M. Slawsky of the NBS Heat and Power Division, the laboratory conducts research basic to the design and evaluation of compressors, storage tanks, accumulators, valves, and other air-borne pneumatic equipment. It also obtains fundamental data in anticipation of future design requirements, develops laboratory procedures for the study of newly developed components, and renders technical assistance in the preparation of specifications for pneumatic devices.

Available facilities include a compressor system furnishing air at pressures up to 500 atmospheres, a specially designed low-temperature box for testing components at temperatures down to minus 95°F at atmospheric pressure, and an altitude chamber capable of simulating conditions up to a height of 80,000 feet.

The altitude chamber has a working volume of approximately 25 cubic feet, which is sufficient to accommodate an entire pneumatic system. Both temperature and humidity controls permit the simulation of flight conditions at high altitudes, and studies can be made over the entire temperature range from minus 100° to plus 150°F. Contained in the low-temperature box is a 3.75-cubic-foot test chamber refrigerated by circulating alcohol from an adjacent bath chilled by dry ice. Air under pressure passes to the component under study through a built-in cooling coil. A flow of 150 cubic feet per minute can be maintained through the system for extended periods at minus 90°F.

The evaluation of pneumatic systems and components involves measurements of pressure and temperature under transient, pulsating and steady-flow conditions, as well as of volume rate of steady flow. The equipment used by the laboratory for this work has been designed to permit automatic recording, adaptability and mobility wherever possible. Static pressures are measured by a bank of Bourdon-type gauges, which are calibrated at frequent intervals against a dead-weight piston gauge of extreme accuracy throughout the range of pressures from 25 to 6000 psi. Transient pressures are determined by means of temperature-compensated strain-gauge pressure pickups calibrated at static pressures. The strain gauge is employed in the usual manner, but the signal is fed either into a recording potentiometer (for slow transients) or through a strain-gauge amplifier to an oscilloscope (for fast transients). Chromel-alumel thermocouples are used to measure temperature. To decrease response time, they are made of 36-gauge wire with as small a junction as possible. For measurements in high-pressure air streams, the thermocouple is built into a high-pressure gland.

The work of the laboratory in the evaluation of pneumatic systems has been concentrated on two problems: (1) determination of the factors governing the most efficient storage and working pressure, and (2) determination of the pressure and energy losses in pneumatic systems during transient flow.

Preliminary calculations on the first of these problems indicate that storage pressures of 3000 psi are justified and

that perhaps even higher pressures may yield further savings in weight and space, but with diminishing returns. The problem is complicated by the variety of possible systems, but there is reason to believe that a rational basis can be developed for estimating the optimum storage and working pressure.

The work on the second problem involves first the study of pressure and energy losses in a pneumatic system during steady flow and then the correlation of these losses with those occurring during transient flow. The results to date give a satisfactory agreement between theory and experiment for steady flow. From a practical standpoint, this means that it is possible to make an *a priori* estimate of the losses to be expected in any given pneumatic system. The theoretical calculations are now being extended to include experimental results obtained under transient-flow conditions.

Although the primary objective of the laboratory is the solution of practical problems in pneumatic design, basic information must be gathered and analyzed in order to understand the relative importance of various design parameters. It is therefore conducting parallel theoretical and experimental investigations on the physical phenomena associated with the thermodynamics and mechanics of fluid flow.

At present the only published data on the high-pressure properties of air are the Joule-Thomson measurements, which extend to 220 atmospheres. To obtain the data needed in this field, the NBS Thermodynamics Section has installed laboratory facilities and apparatus for measuring the pressure-volume-temperature (PVT) relations of air from the lowest temperatures to 350° Kelvin (170°F) and at pressures up to 300 atmospheres. With the application of existing theory, the experimental measurements obtained in this range will permit accurate determination of the thermodynamic properties of air at the high pressures being considered for future designs. The apparatus can also be used for PVT measurements on other technically important gases that have been considered for pneumatic applications.

STORAGE TANKS
Each vessel contains 10 cubic feet of air under a pressure of 3000 psi.

On the basis of the existing data for the principal constituents of air and the limited data for air itself, tentative tables and charts of the thermodynamic properties of air have been calculated from 2 atmospheres to 5000 psi. The Joule-Thomson coefficient, specific heat, enthalpy and entropy have been computed as functions of temperature and pressure, and graphs are in preparation.

Study of a large variety of pneumatic components has brought to light several inadequacies in current pneumatic testing practice. Some of the commonly accepted definitions and test procedures have proved to be ambiguous. As a result, it has been necessary to reëxamine the bases on which existing tests were set up. A careful analysis has been made of the performance of various components to determine the elements or characteristics that are of real importance to their proper operation.

In the course of this work, a method was worked out for describing the pressure drop across any pneumatic component in terms of a single characteristic curve.* This new approach permits the rating of a valve with extreme economy of time and much less ambiguity. Previously, the flow characteristics of a component were described by a family of flow curves, which were plots of flow rate versus downstream pressure for various values of upstream pressure. Numerous careful measurements were necessary to provide the data for such a set of curves. Bureau workers investigating the problem found that when the ratio of the downstream pressure to the upstream pressure is plotted against the ratio of the flow rate to the upstream pressure, a characteristic curve is obtained which is unique for the component under study.

Moreover, inasmuch as analytical formulae are available for plotting these characteristic curves, and all have one point in common, any given characteristic curve is completely determined by specifying one other point. Thus, NBS study shows that the complete behavior of a pneumatic component can be specified simply by the measurement of a single value of the flow rate for a given value of the ratio of downstream to upstream pressure. The value of the flow rate where the ratio of pressures is 1:2 has been designated the "flow factor" and is used by NBS to describe the complete behavior of a pneumatic valve in terms of a single quantity. The flow factor is a constant for a given component, and once it is determined either by experiment or theory it can be used to predict valve performance for a wide range of upstream conditions. It is also possible to combine analytically the flow factors of a number of valves into an over-all flow factor, which will serve to determine the behavior of the more complex system composed of the separate valves in series.

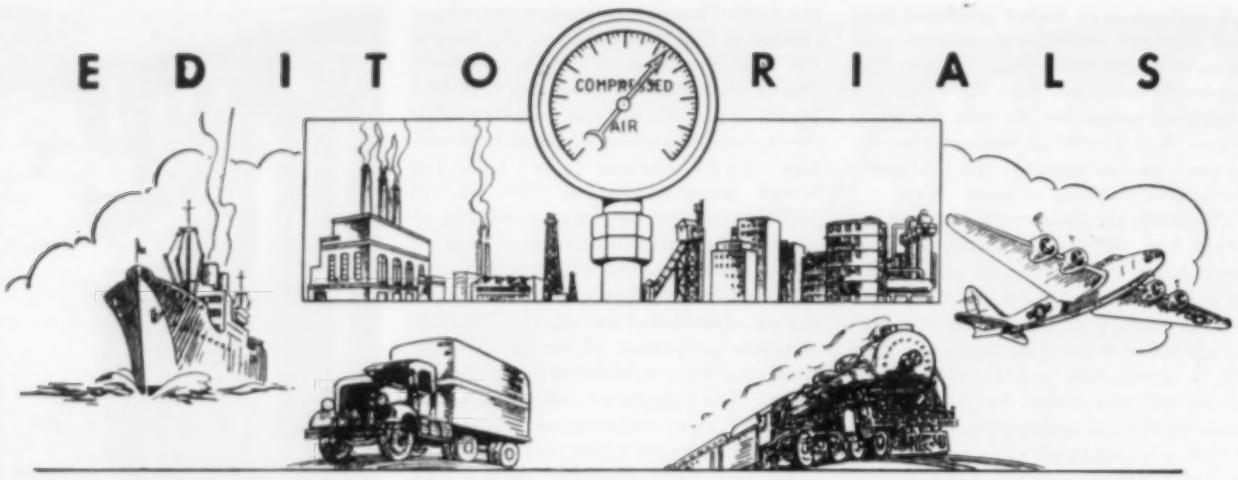
GAUGING HIGH-PRESSURE AIR
Mobile instrument and control panel for measuring the flow of high-pressure air.

In the short time since its establishment, the pneumatics laboratory has made progress in the development of facilities, instrumentation, and experimental and theoretical techniques for the analysis of pneumatic systems. Continual effort has been made to maintain a balance between the practical and sometimes urgent requirements of the designer and the more basic aspects of the problems studied. It is believed that time spent on the more fundamental studies will eventually be of great value in the solution of technical problems arising in connection with pneumatic systems where high flow rates, short response time and rigid cycling schedules are specified.

*"A Method for Predicting Pressure Drops in Pneumatic Systems," by M. M. Slawsky, A. E. Schmidlin and Molutzky, S.A.E. Preprint No. 81 (1953).

EDITOR'S NOTE: Summary of a technical report published recently by the National Bureau of Standards.

EDITORIALS



HE REVISED OUR ROAD MAPS

THE man who had more to do with creating our nation-wide highway system than anyone else recently retired from active service. He is Thomas H. MacDonald, and he did such a good job as head of the Bureau of Public Roads for 34 years that no president, regardless of political affiliations, dared risk displacing him. Starting in 1919, or shortly after the Federal Government became interested in highway affairs, he administered its expenditures of billions of dollars and largely formulated its policies. In all truth, he revised the highway map of the country and guided the transformation from mud and ruts to macadam and concrete.

When MacDonald was called to Washington he was, at the age of 38, already a veteran and an expert in highway matters, previously having devoted sixteen years to that field of work. There was, we are sure, little serious interest in roads in 1904. Henry Ford had been building automobiles only a year, and there wasn't a gasoline filling station in the land. Yet at that time young MacDonald entered upon his career in road designing, although the truth is that his first efforts were aimed at smoothing the way for plodding Dobbins rather than rubber-tired Tin Lizzies.

In 1904, MacDonald was a 23-year-old senior student in civil engineering at Iowa State College, to which he had transferred after a year at a teachers' college. For some reason he had exhibited a liking for highway engineering, although we wonder if that term had then come into usage. Fortunately for the motoring millions who were to throng the roadways in afteryears, Iowa State had Dean Marston, an excellent educator with a keen understanding of his students and a desire to direct them along the lines in which they showed the most talent. At his suggestion, MacDonald based his graduation thesis on a study of the farmers' needs of highways and the force required to pull a wagon over different types of roads.

In the same year the Iowa Legislature designated the college to investigate the state's rather crude roadways and to make recommendations for improving them. MacDonald was assigned the task with the rank of assistant professor. This led to his appointment as state highway engineer in 1907. Six years later, when the highway law was revised to create a commission with authority to coördinate roadbuilding throughout the state, he was made chief engineer. In that post he had a hand in Iowa's becoming one of the first states to establish an integrated road system. Approximately one-third of the 6400-mile network had then been graded, drained and adequately bridged, and plans were being drawn to begin hard surfacing it when MacDonald was asked to go to Washington to take charge of the national-highway effort.

Federal Aid to the states in roadbuilding had been authorized by Congress in 1916, but had not been put into effect, and getting it going was MacDonald's first big job. At the outset he sought the advice and coöperation of state-highway officials, a practice that he continued to follow. As a result, there was rarely friction between national and state highway interests. When Federal Aid was instituted, practically all industrial plants were strung along railway lines, there were no surfaced roads connecting the large cities and farmers were mostly isolated. All this was altered during MacDonald's tenure in office.

He gained world-wide acceptance as an authority on highway matters and received numerous honors and decorations from foreign governments. Realizing the value of obtaining public support of his actions, he wrote profusely on the subject of roads and spoke frequently at highway meetings throughout the nation. His office was unblemished by suspicion of wrong doing of any kind and was never the target of investigators. Upon his retirement, a national highway magazine, *Roads and Streets*, editorialized him under the heading "Mr. Highway." Unquestionably, the title fits him, and he earned it.

FLUID-POWER PROMOTION

MANUFACTURERS of similar types of equipment have common problems and objectives. For example, though they may compete with one another, all are eager to advance their branch of industry and to promote the use of their products in preference to others that may be offered for the same purposes. They are also mutually concerned with establishing and maintaining certain standards to make sure that their commodities will win public acceptance and confidence. In short, there are many things that can be handled best by the industry as a whole rather than by its individual members.

To make such concerted action possible and to provide a clearing house where ideas of common interest can be brought under discussion, makers of like products, from pins to perambulators, have adopted the medium of the trade association. It is an old idea and one that works for the best interests of both members and public. In times of national emergency, for instance, it provides the machinery for quickly bringing about coöperation among the entire membership for the purpose of supplying materials and equipment essential to security.

A recently organized group of this kind is the National Fluid Power Association. It includes manufacturers of such things as pneumatic and hydraulic valves and cylinders and related products, all of which are steadily becoming more important in various industrial processes. At the organization meeting, 45 of these concerns were represented. They elected officers, adopted a statement of objectives and took care of other preliminaries to active functioning.

The term "fluid power" as defined by the group refers to all systems for the transmission, application and control of hydraulic and/or pneumatic power. All American concerns engaged in the design, production and distribution of components of these systems are eligible for membership in the association.

This and That

Britain's Largest Casting

A 170-ton steel casting, the biggest ever poured in the British Isles, was recently shipped to the United States for incorporation in a machine being built here in connection with the defense program. It is one of several turned out by the English Steel Corporation, Limited, of Sheffield. Three open-hearth furnaces were required to produce the 210 tons of liquid metal used in pouring it. After allowing six weeks for cooling, the massive casting was loaded onto a specially constructed truck for transport to a pier in Liverpool.

* * *

Spray-on Surgical Bandages

A plastic film called Bonoplast is being used successfully in Sweden as a substitute for the traditional surgical dressing of cottonwool and gauze. It is a viscous liquid that dries into a transparent, pliant film a few minutes after application. It has the same degree of permeability as the human skin and thus permits the latter to "breathe." Moisture given off by the skin passes through it instead of accumulating, and hence does not obscure the view of the wound or incision. In the same manner, blood seeps through and can be wiped away.

Besides serving to dress cuts or scratches, the plastic is put on prior to surgery. Following the operation, the edges are sewn together with fine stainless-steel wire, forming a sterile covering that permits physicians to observe the incision as though through a window. In a few days the stitches are removed and the layer is peeled off. Small quantities of the material are spread on with a spatula, but in the case of areas of considerable size, it is sprayed on with an air gun.

Bonoplast was developed by chemists of the Swedish Bofors Armament Works by modifying plastics the firm supplies for use in lacquers. They worked for two years to give the film the desired porosity and also to impart the necessary adhesiveness to the liquid so it would stick to the skin. A similar product is now being made in England.

* * *

Did You Know?

An air slugger isn't a bludgeon. It's just a name coined on a job to designate the method that helped place some concrete where it was wanted. In lining the steel-supported arch section of the Gaviota Gorge Tunnel of the California highway system, it was necessary because of restricted headroom to divide the delivery end of the line carrying concrete from a Pumpcrete machine. In order to direct the discharging material as desired and to push it away from the ends of the pipes and into the furthermost recesses of the form, three compressed-air connections were made. One was about 2 feet back of the line's branching point and the others were in the wye, one in each leg. The name air slugger was given this aid by John E. Witte, resident engineer, who described the project in the May-June issue of *California Highways and Public Works*.

* * *

Salvage from Storm

Here is another instance of an ill wind blowing good. In the forests of northeastern Scotland a storm toppled an estimated 40 million cubic feet of timber, but approximately one-third of the wood can be used for pit props and other purposes in the coal mines of the British Isles. As a result, less timber will have to be imported during the next two years. The National Coal Board has arranged to send men and machinery into the affected area to help harvest the windfall.

* * *

Oak Ridge Ceramics Research

Finding suitable materials for the construction of reactors or atomic furnaces is one of the knotty problems involved in the development of nuclear-power equipment. Reactors operating at temperatures exceeding 800°F may prove to be the most economical. Ceramic materials can perhaps withstand great heat better than metals, and they have shown special promise for use in building low-cost "power-package" reactors.

The ceramics department of the Oak Ridge (Tenn.) National Laboratory, which is operated by Union Carbide & Carbon Corporation, is devoting most of its efforts to searching for acceptable heat-resistant materials. Cermets, combinations of ceramics and metals, are under study, and oxide, boride and nitride ceramics are being tried out in structural roles. The goal of another line in the investigations is the development of satisfactory techniques for applying ceramic coatings to materials for reactors. One method, which is illustrated, consists in spraying a finely powdered ceramic with compressed air through a flame and onto the surface to be covered.

* * *

Cobalt's Novel Clan

It came to light last month during the celebration of the fiftieth anniversary of the discovery of mineral at Cobalt in Canada that a unique organization existed there in the early days. It was called the Fifty Centers because its members kept a half-dollar in their pockets at all times to meet such exigencies as buying a final meal before going broke or helping out a fellow miner or prospector who was up against it. The money was never spent unless a real emergency arose. Old-timers revived the society for the period of the festivities and initiated various prominent visitors into the camp by requiring each one of them to toss a half-dollar into a pot.

* * *

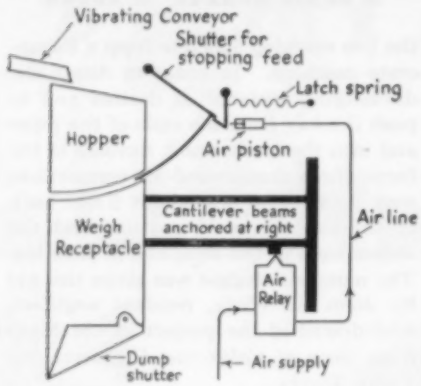
Continuous Concrete Mixing

A German firm is manufacturing a concrete mixer that functions continuously, in contrast to the intermittent action of conventional equipment. Mixing is done by a screw that turns in an elongated chamber, which is inclined at an angle of 22° from the feed end so that the materials tend to fall back for additional mixing during their upward progress. Batching of cement and aggregates from four hoppers, which can be filled by hand or conveyor belts, is automatic. Water is introduced through a hose line at a constant rate maintained by regulating the tap. The machine is 9 feet long, 5 feet high and 43 inches wide, weighs 1500 pounds and is mounted on a pair of wheels. It can be run by either a gasoline engine or electric motor and operates at two speeds, one of which turns out 6½ cubic yards per hour and the other 10½ cubic yards.

Air Controls Overweight in Packaging

IF EACH seven-ounce package of breakfast food put up by General Mills averaged ⅛ ounce overweight, the annual loss would amount to $100,000 at the present rate of production. It therefore behooves the corporation to make sure that the filling equipment used is as accurate as it is possible to make it, for any unit reduction, no matter how small, means an appreciable saving. To this end the company installed a new type of weighing machine at its Buffalo, N.Y., plant a little more than a year ago and recently added another. Of the straight-line multihead type, it has lowered the average overfill in the case of Wheaties to a fraction of ⅛ ounce, the specific weight tolerance obtainable depending upon the nature of the product.

The scale mechanism, known as the Pneumatron, works on the same principle as air-operated automatic control instruments and is shown in simplified form in the accompanying diagram. The cereal to be packaged is fed by the vibrating conveyor into the hopper, from which it flows into the weigh receptacle. As it does so, the cantilever beam is deflected downward, narrowing by a few thousandths of an inch the gap between a flat plate and a tiny jet that directs a minute stream of compressed air against it. Restriction of the space increases the pressure in the air line leading to the nozzle and causes the relay to admit air to the latch-spring piston. This closes the feed shutter and thus stops the flow from the hopper into the weigh receptacle. Its contents are then dumped by way of a funnel into the package spotted beneath it, the shutter is again opened and the cycle is repeated. When lined boxes are filled, the lining is spread by means of a suction hood attached to the bottom of the funnel.



SINGLE-FEED SCALE MECHANISM

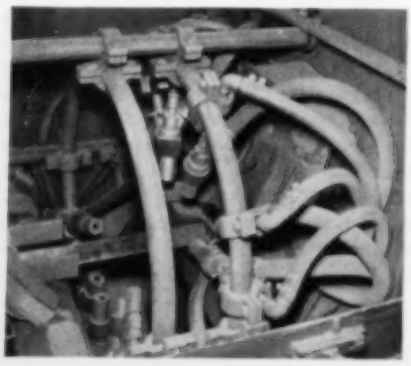
For products that present a weighing problem, there are twin-scale mechanisms. In this case each hopper has two shutters at the outlet end, one for feeding a large stream and the other a small one. The big one closes when the weight of the material is nearly equal to that of the full contents of the carton, leaving the little one to finish packaging in driblets until the specified weight is reached. A 4-scale dual-weighing machine running at top speed is said to fill 90 boxes a minute with precision and a single-weighing 4-scale Pneumatron 140 cartons a minute.

Grit-blasting Machine Gives Satin Finish

A NEW type of sandlbasting machine, which gives a satin finish to the 40-foot spar rails used in the wings of modern airliners, is expected to save Consolidated Vultee Aircraft Corporation, of San Diego, Calif., approximately $35,000 during 1953. Before the unit was installed, the aluminum-alloy rails were polished tediously by hand. About 40 man-hours were required to process one rail, and the finish attained in each case depended upon the skill of the worker on the job.

With the new equipment, two men can do all the polishing with unprecedented speed and uniformity. A conveyor belt feeds the metal rails at the rate of 10 feet per minute through a boxlike chamber in which each is attacked from all sides and angles by particles of aluminum oxide ejected from a series of nozzles by compressed air. At present, 180-grit oxide is being used and gives the work a 70 to 100 microinch finish. However, virtually all other kinds of abrasives can be applied at pressures varying in accordance with the finishes desired and controlled by conventional reducing valves.

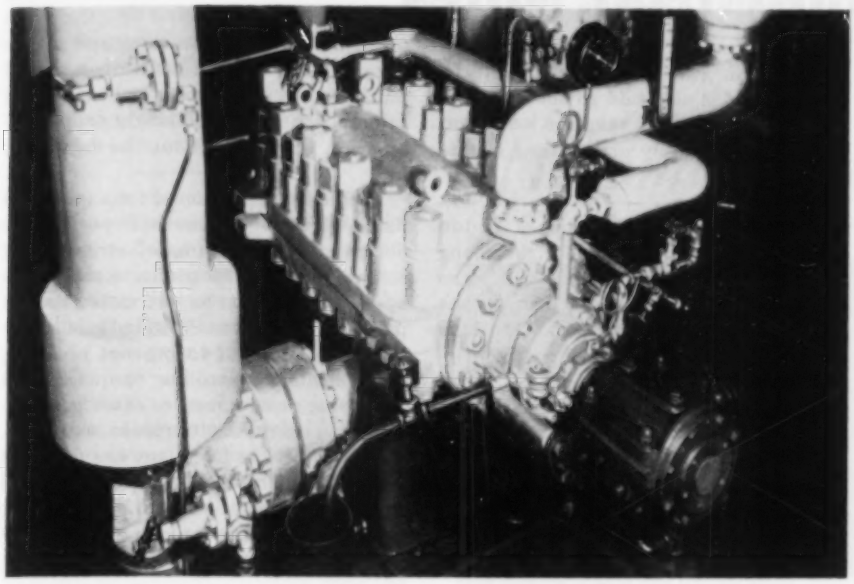
Before a part is processed it is examined for scratches or gouges. If deep, they are smoothed out; if slight, the peening action of the grit wears away their sharp edges and causes them to disappear. As a rail leaves the blasting chamber, any particles of aluminum oxide clinging to it are removed by blasts of air issuing from a second series of nozzles. The finish obtained is said to be so smooth that no handwork is required and facilitates building up the oxide coating which serves as a primer for the conventional organic finish that is eventually applied to prevent corrosion.



MACHINE AND ITS NOZZLES

General view of the Pangborn enclosed blasting unit with a spar rail emerging after it has been cleaned and polished. Above is a picture inside the cabinet showing the intricate radial assembly of hoses and nozzles surrounding a rail section in position for surface finishing.

Boiler Feed Pump Has Run 100,000 Hours



MARATHON RUNNER

This boiler feed pump has not been opened since it went into service in 1938 and is still operating regularly. It delivers 1000 gpm of 380°F water at 1900 psi pressure.

MANAGER R.F. Kellogg of the Beech Bottom Power Company's Windsor station at Power, W.Va., recently reported that an Ingersoll-Rand high-pressure boiler feed pump had successfully passed its 100,000th hour of operation without having been opened for inspection or repair. This outstanding service record has been compiled in the fifteen years since the unit was installed during an expansion program that increased the plant's capacity to 240,000 kw. To put the performance in terms more understandable to the layman, engineers have likened it to that of an automobile circling the earth 160 times at 40 miles per hour without an engine overhaul.

Many pump manufacturers advocate letting a boiler feed pump alone so long as it is operating satisfactorily, but recommend keeping a weather eye on instruments and controls that indicate loss in head or capacity rating or an increase in power consumption. These are symptoms of internal wear, and their extent is a good index of the immediacy of the repairs a machine may require.

Maintenance of the 7-stage horizontally split pump, designated as Class HT by its manufacturer, has been limited to infrequent repacking even though the unit operates under 415 psi suction pressure and at 380°F. temperature. The axial thrust of its 9-foot-long rotor, with in-line arrangement of its stages, is neutralized at the high-pressure end by a balancing drum, which also breaks down the 1900-psi discharge pressure to suction pressure. Despite the differential of nearly 1500 psi none of the parts of the breakdown has had to be renewed.

Behind the pump's impressive performance lie years of metallurgical research carried out by the manufacturer in an effort to develop materials best suited for boiler feed service, which is admittedly severe. But even with all this and a high order of workmanship, the machine could not have performed as it has without the power plant's careful operation and feed-water control.

Though overshadowed by their counterpart, five other HT boiler feed pumps in the Windsor station have had similar successful maintenance records. Four of them, installed at a later date, have each piled up from 50,000 to 80,000 unopened hours of service. The other one, which was set up at the same time as the 100,000-hour unit, was opened for inspection a few years ago—unnecessarily, as it developed, because there was no need of repairs. It was put back in service unaltered. It may be that that has had something to do with setting the performance record, which is a credit to both the maker and the Windsor station.

Mill Saws Chilled Wood

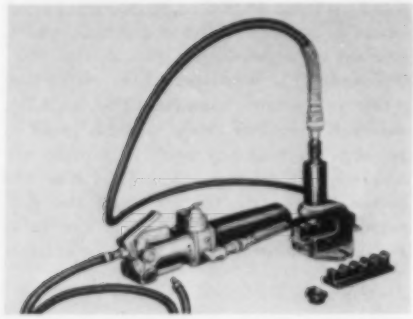
PUTTING lumber in a cooler sounds like borrowing trouble, but that is actually done by the Birds-Eye Veneer Company at Escanaba, Mich., to avoid trouble. The concern handles basswood which, apparently, cuts smoothly only in cold weather. Formerly the mill had to shut down during the hot season because the edges of the thin sheets of veneer were rough and uneven. All sorts of cutting and processing methods were tried without success until the concern conceived the idea of chilling the lumber.

The refrigeration unit built is 20 feet long, 15 feet wide and 12 feet high and is closed at one end by an upward-swinging door through which a loaded carrier can pass freely. The installation consists of a 3-hp compressor outside the room and three forced-air cooling units suspended from the ceiling. When first tested, it reduced the temperature of 5000 board feet from a maximum of 90° to 48°F in 24 hours, and now regularly maintains the lumber at just below 40°, at which it is in the best condition for cutting.

AMERICAN MACHINES ABROAD

This street scene in Tel-Aviv, Israel, looks much like one at home. It shows employees of the Tel-Aviv Municipal Corporation making ready to resurface a street. Some of the men at the right are wielding picks, while two others are operating paving breakers. Air for running the tools comes from an Ingersoll-Rand 210-cfm Gyro-Flo compressor (left) that has been in steady service for a year without requiring attention other than routine maintenance and fueling.

Industrial Notes



For the purpose of applying terminals as well as splices on No. 8 to 4/0 aircraft cable, Burndy Engineering Company, Inc., is offering a new rack-type Hypress that is said to exert an indenting force of 9000 psi with air at 60 psi, line pressure. The tool consists of an air-hydraulic pump and of a hydraulic cylinder and ram mounted in a frame together with a sliding rack with standard nest contours. The work can be fed either from the side or the front, and a spring-loaded pull button on the frame accurately spots the rack under the indentor. Standard indentors are used, but they are permanently fixed in special adaptors that shoulder against the rack. This insures control of the depth of the indentation and enables the operator to see when the work is completed.

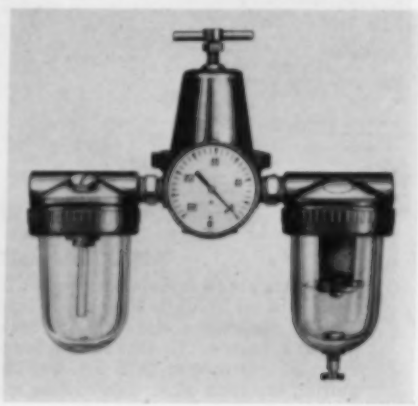
Corrugated plywood is being produced on a commercial scale for industrial and construction purposes by presses invented by a Brazilian engineer. Interposed between the platens of the new machine are several wave sections that are separated from them by springs. These are longest at the center so that when the press is closed the plies are brought in contact with the molds progressively from the center outward. Pressure and heat are applied after the corrugations are formed. They are said to be permanent. The material is now being tested in the United States. According to reports from the Brazilian Technological Research Institute of Sao Paulo, sheets 30x80 inches in size withstand a pressure of more than a ton. The veneer weighs less than a pound a square foot and has been used to build houses with roofs supported by the walls without the use of vertical wooden studs. At present, its principal application in Brazil is as a roofing material.

A clutch equilibrator is now standard equipment on all Diamond Multi-Max punch presses and shears, according to an announcement by Diamond Machine Tool Company. The device consists of two parts—a heart-shaped cam and an air chamber with an automatic pumping and regulating mechanism—and serves to counterbalance the punch and die plates that vary from one setup to another. It is also said to act as a frictionless brake and to take the load from the clutch assembly at the time of disengagement.

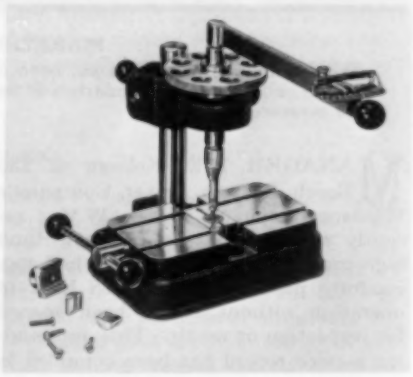
Powered by a gas turbine, a 27-ton truck-trailer recently made a run along the Pacific Coast from Canada to Mexico in 60 hours. The revolutionary prime mover weighs only 200 pounds, or 3000 pounds less than the diesel engine originally installed in the vehicle.

It is reported that The International Nickel Company advanced the underground workings of its productive mines in the Sudbury District of northern Ontario, Canada, about 25 miles in 1952, giving them a total length of 325 miles!

Arrow Tools, Inc., has announced a new filter-regulator-lubricator that is said to embody a number of distinctive features. Air entering the filter is subjected to centrifugal action which throws some of the entrained moisture and solids against the walls and down into the bottom of the transparent bowl from which the deposit can be withdrawn through a drain cock. Housed in the filter is a porous bronze element with a baffle at the lower end. The latter creates a relatively quiet zone from which the air flows up and through the bronze element which, it is claimed, removes even the finest particles remaining and holds a greater than normal amount of foreign matter without a serious loss in pressure. The element can be taken out for cleaning. This is done by blowing compressed air into it to dislodge the material clinging to the outer surface. The lubricator has a porous bronze feeder wick that forces the oil into the air stream in a fine mist, the quantity delivered ordinarily varying automatically with the flow. If not, the elevation of the wick can be changed to feed more or less oil, as desired. Improvements incorporated in the regulator include: a positive-action self-bleeder to prevent pressure build-up in dead-end applications and a diaphragm of a new oil-resistant material reinforced with nylon cord. Units of the assembly may be used singly or in combination with or without the regulator.



Because of the demand for a universal fixture that would make it possible to determine the ultimate strength of screws or threaded connections and to apply proof loads; to test materials and parts where torsional strength is an ultimate factor; and to prevent breakage by accurately controlling torque applied in driving nuts, screws or other parts requiring controlled torque in assembly, P. A. Sturtevant Company has designed an instrument that is said to meet all these requirements. Two models with capacities of 0-200 inch-pounds and



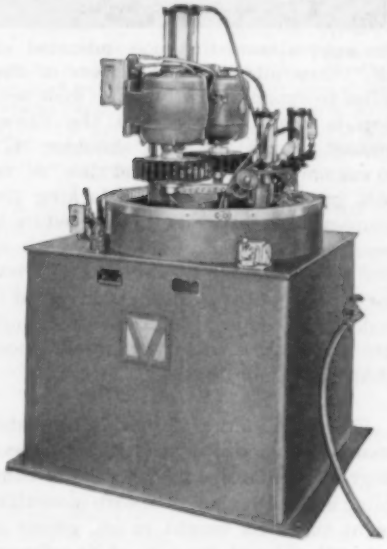
0-150 foot-pounds are now in production and are operated by a torque wrench through an adjustable spindle with a female drive square that allows a wide choice in wrenches within the limits of each fixture. The latter includes a standard male drive-square attachment that is fitted to the threaded driving end of the spindle and permits the use of regular sockets, socket screw drivers, etc., without alterations. The model illustrated shows a screw undergoing test to determine its ultimate strength—a typical application.

Turbine discharge pressure on jet engines is being controlled by a tiny pneumatic device developed by the Solar Aircraft Company. Known as Microjet, it is said to compute automatically what the discharge pressure should be under all flight conditions. When there is a discrepancy between the actual and the ideal pressure, it causes electric signals to flash the fact to other engine controls which adjust the pressure.

Under the trade name Commander, The B. F. Goodrich Company is offering a new heavy-duty air hose for mine and quarry service, construction projects and general industrial use where pressures

up to 400 psi may be required. The hose is reinforced with a single braid of high-tensile steel wire and is oil resistant both outside and inside so lubricant can be fed through it to the tools. It has a light-gray cover for increased visibility underground and is made in ½-, ¾- and 1-inch sizes.

Jet-engine stator rings, half rings or circular workpieces made up of more parts can be deburred on a high production basis, it is claimed, by use of a new turntable-type machine developed by Grinding & Polishing Machinery Corporation. Rings or sectional rings varying in diameter are individually clamped by interchangeable 3-jaw holding fixtures to a master ring rotated by a ½-hp motor through a constant-speed spur gear. As the table turns, six wheel-shaped wire brushes are brought into action. These operate in sets of two running in opposite directions and are brought in contact with the work by pneumatic cylinders using air at 90 psi. Two large polishing-head units are mounted on vertical spindles driven by 1-hp motors and remove the burr from those parts of the broached slots that are on the flat inside diameter of the ring. The sections where the slots break through the side wall of the channels at the edges of the ring are deburred by two pairs of small wire brushes operated by two pairs of angularly mounted air motors. One set finishes the top edge and

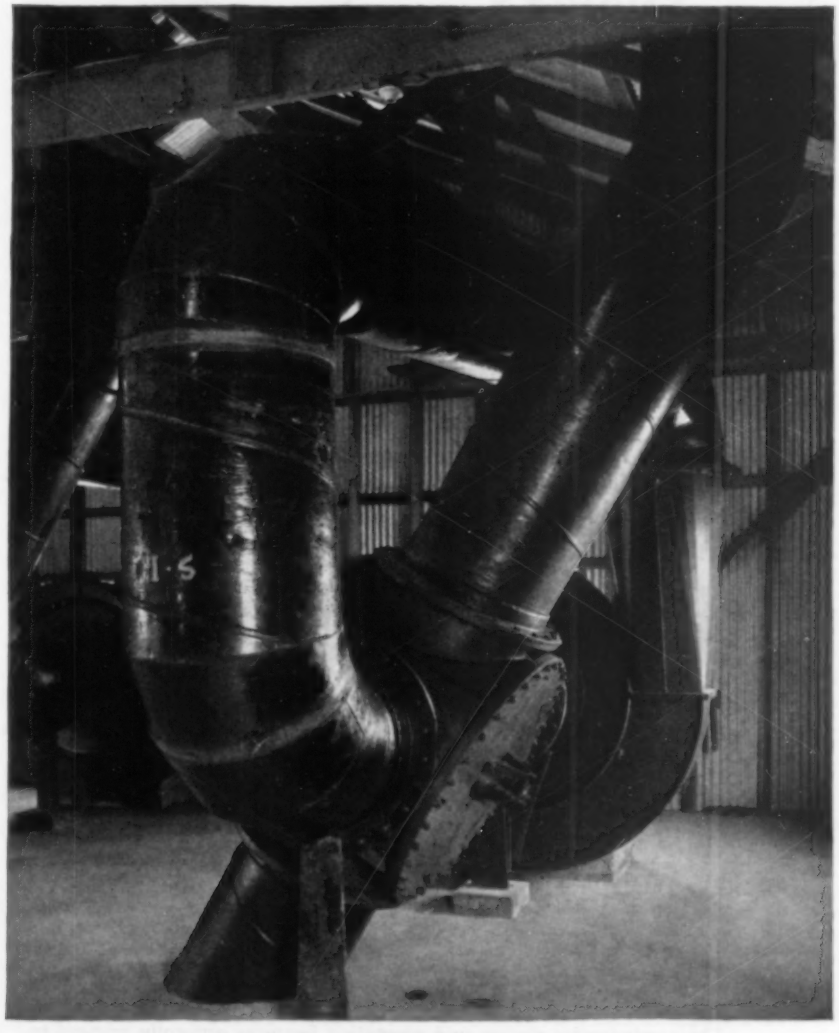


EXPEDITES DEBURRING

The new turntable deburring machine with two half rings locked to the master ring and with brushes raised. Only two pairs are shown: the large brush-head assembly, which is positioned by the pneumatic cylinder above it, and, right, the top pair of smaller wire brushes which, together with their air motors, are lowered and lifted by the left-hand cylinder. The outer one controls the bottom pair. The master ring makes 12 rpm. By using variable- instead of constant-speed drive it can be rotated 5.5 to 55 times a minute.

IRON LUNGS

for Underground Operations



You'll breathe easier with air lines of Naylor lightweight pipe feeding fresh air and removing fumes and stale air from your underground operations. It's the safest and most practical vehicle for push-pull ventilating service. Bulletins No. 507 and No. 514 will give you the full story.

NAYLOR PIPE COMPANY
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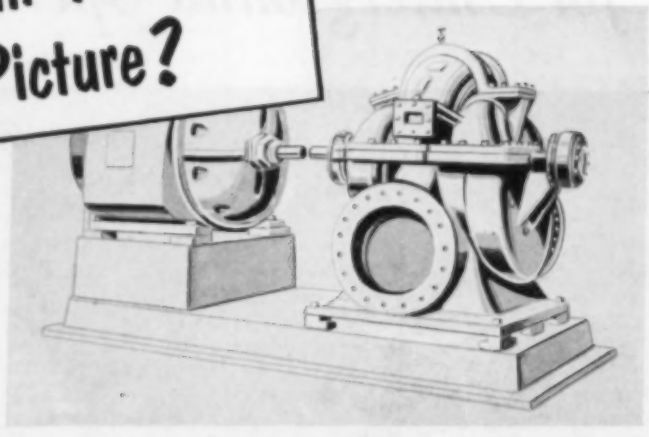
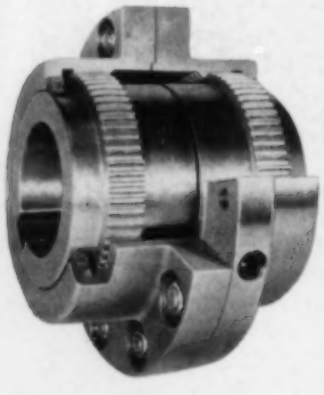
What's Missing In This Picture?



It is the one thing that will make these two pieces of equipment operate properly—a SHAFT COUPLING. Any shaft coupling will permit the motor to drive the pump. But the frequency of shutdown for repairs and the extent of damage to costly equipment depends entirely on the design, construction and quality of the coupling installed. To insure longer trouble-free operation, more and more buyers specify the

WALDRON *Improved* GEAR TYPE Couplings



Their noteworthy design and operating features naturally appeal to men who understand transmission problems and requirements. All steel construction for maximum ruggedness; one piece cover sleeves; accurately crowned gear teeth; longer lining up surface; absence of all adverse crank action on shaft and bearing—these and other features combine to eliminate the usual causes for coupling failure.

Available in all types and sizes—design easily adapted for special applications. Write today for descriptive catalog and specific engineering data.

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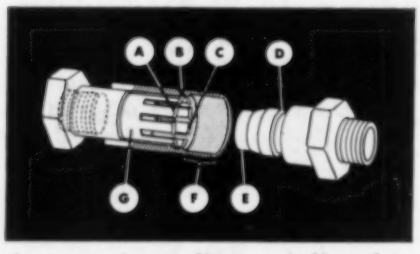
the other the bottom edge. The motors are reversible so that the brushes can be reversed to prevent the bristles from becoming set. All control equipment such as push buttons for the electric motors, valves for the pneumatic cylinders and for changing the direction of the air motors, and the clutch lever are mounted on the machine's fabricated steel base. According to the records of one user, 32-inch aluminum half rings were loaded, deburred and unloaded at the rate of two a minute—a complete time cycle. By previous hand methods it took eight hours to finish a set of 24 half rings.

A quick coupling based on a new principle and developed by Corley Sales & Engineering Company for use in the aircraft industry is now being offered for general application. With ends adaptable for any standard connection, it is suitable for linking flexible cable, tubing, hose or piping carrying liquids or gases under varying pressures; for hooking tractors to trailers and agricultural implements; and, with an integral ball and socket, for joining control rods. Coupling is effected by moving the sleeve back



the approximate distance indicated at "F," thus allowing the fingers of the collet to expand slightly. The male section is then inserted and the sleeve pushed forward, causing shoulder "C" to engage shoulder "D" and ribs "A" to seat in slot "B," securely locking the coupling. To break it, the procedure is reversed. Normally, a simple type of seal is used where "E" engages "G," but for service where pressure is involved it is designed to meet requirements. Standard checks can be incorporated where shutoff is essential.

Finely ground cellulose is available under the name of Cottontex for use as a degreasing and drying material in tumbling mills. It is said to absorb more than eight times its weight in oil, grease or other liquid and, because of its softness, to protect parts such as bearings during the processing operation.

Construction and lumbermen, survey parties, hunters, campers and others that venture into snake-infested country can safeguard themselves against poisonous bites by wearing trousers of heavy canvas with a detachable lining woven of fine Monel-metal wire. Designed by the Gokey Company, the garment is said to provide thigh-high protection.

Industrial Literature

American Brake Shoe Company has issued a 12-page booklet on the properties, characteristics and applications of its three standard grades of Ductalloy (trade name for its ductile iron). Typical castings for use in aviation and chemical, diesel and general industrial fields are pictured. Write the company to Dept. A, 230 Park Avenue, New York 17, N.Y., for a copy.

Bulletin UA-530 recently released by the American Brass Company describes its "Sealtite," a flexible liquid-tight conduit for electrical wiring that is said to be the first of its kind to win the approval of Underwriters' Laboratories for service in wet locations. Copy may be obtained by addressing the company's American Metal Hose Branch, 692 Main Street, Waterbury, Conn.

Aluminum in Materials Handling is the title of a 20-page illustrated booklet containing reprints of six articles covering the results of a survey made by The Aluminum Association of more than 50 manufacturers and users of equipment of this type. The publication can be obtained from the Association, 420 Lexington Avenue, New York 17, N.Y., by writing request on company letterhead.

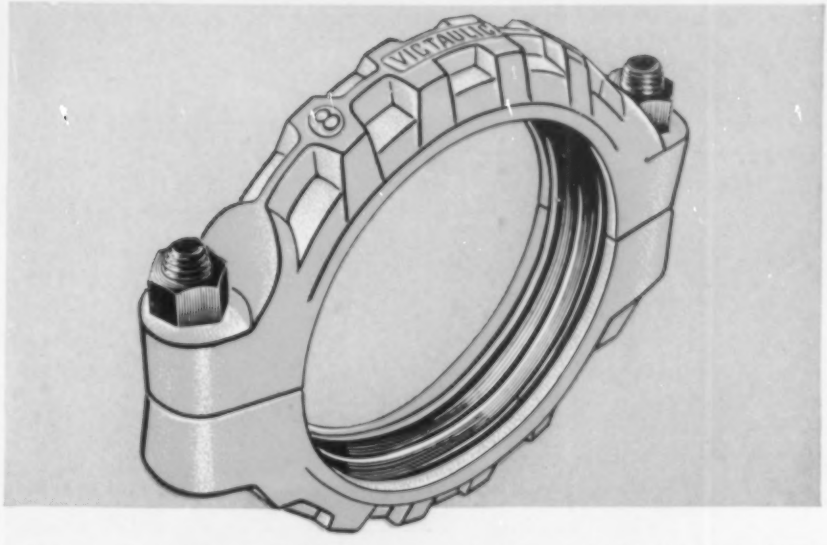
A new bulletin, F 5783, issued by Wheelco Instruments Division, Barber-Colman Company, Rockford, Ill., deals with its Model 200 Series Capacitrols—direct reading on-off, proportioning and anticipating temperature controllers. Included is a description of its new Capaciline or "straight-line" Models 221C and 224C, units that anticipate the approach or departure of temperature from the control point.

Bailey Meter Company, 1050 Ivanhoe Road, Cleveland 10, Ohio, has released a catalogue—No. 18—giving information on its complete line of control equipment, meters and engineering services. Written for engineers in public-utility, power and process plants, it lists fifteen measured variables that are common to such plants and form the index for the selection of appropriate metering and control equipment.

A recent Circular, No. 558, prepared for free distribution by The Lunkenheimer Company, Box 360-U, Cincinnati 14, Ohio, describes the functions of its nonmetallic disk valves and lists those that can be renewed or converted for other services by the insertion of any one of three types of special disks designed for use with saturated steam; cold water, air or gas; and gasoline, oil, butane or propane.

Heli-Coil Corporation has announced the availability of a completely revised catalogue on its Heli-Coil or wire screw-thread inserts. Of 22 pages and spiral-bound for convenience, it introduces new specifications for inserts covering Class 2, 2B, 3 and 3B fits and explains their uses by aid of photographs and drawings. Requests for Catalogue No. 652 should be addressed to the corporation at 1360 Shelter Rock Lane, Danbury, Conn.

Pelron Corporation, 7700 W. 47th Street, Lyons, Ill., has announced a new brochure dealing with the services it is equipped to render the finishing industry. The company makes studies of special problems relating to metal cleaning, phosphating, paint stripping and paint-booth operations and recommends and develops compounds to meet specific needs. Also included is a description of its standard products for finishing metals.



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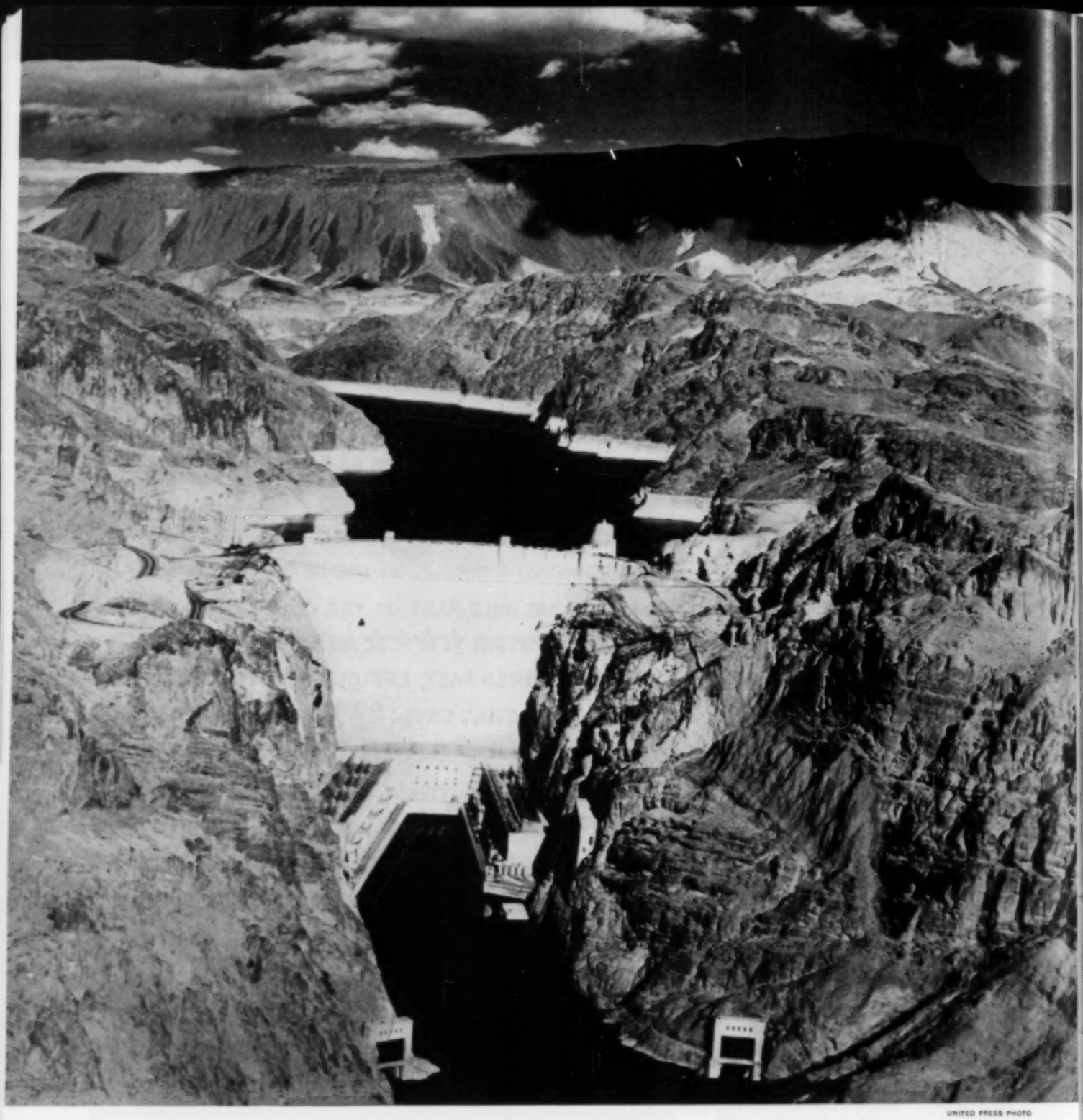

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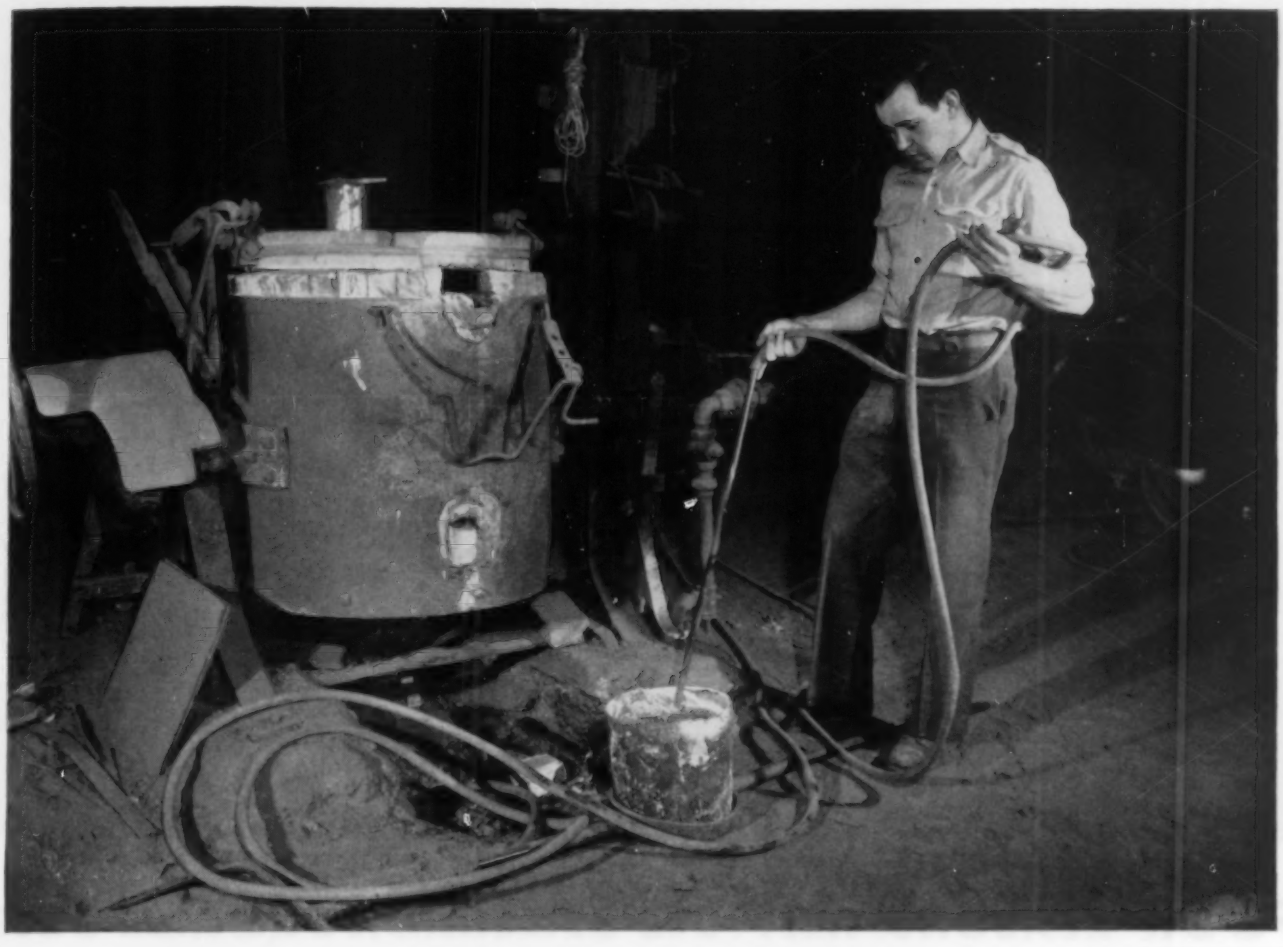

This hose handles 85% of all air hose jobs—lasts for years

Saves days of waiting for special hose—saves money too

HERE is the most useful air hose made. It's B. F. Goodrich Type 50, built to handle 85 out of every 100 air hose jobs, and last longer doing them. Here's why:

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The tough rubber tube withstands heated air even when it contains lubricating oil. Will not break into loose, gummy particles that clog tools. Cover is oil-resisting, too. Type 50 can be dragged through oil or grease without damage.

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Cover is abrasion-resisting. Scraping over rough floors, rocks, cinders or roads won't tear it. Won't check or crack from constant sunlight.

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Resistance to heat and hard knocks is vital in the foundry pictured above. But in spite of rough treatment, that length of Type 50 has been in service 25 years now, still looks good for a lot more use. B. F. Goodrich Type 50 is also recommended for shop tools, tampers, fixed and portable compressors, air hoists, quarry and mining service.

B. F. Goodrich distributors have Type 50 for immediate delivery, but if you would like more information before you buy, send the coupon below for a descriptive folder. No cost or obligation, of course.

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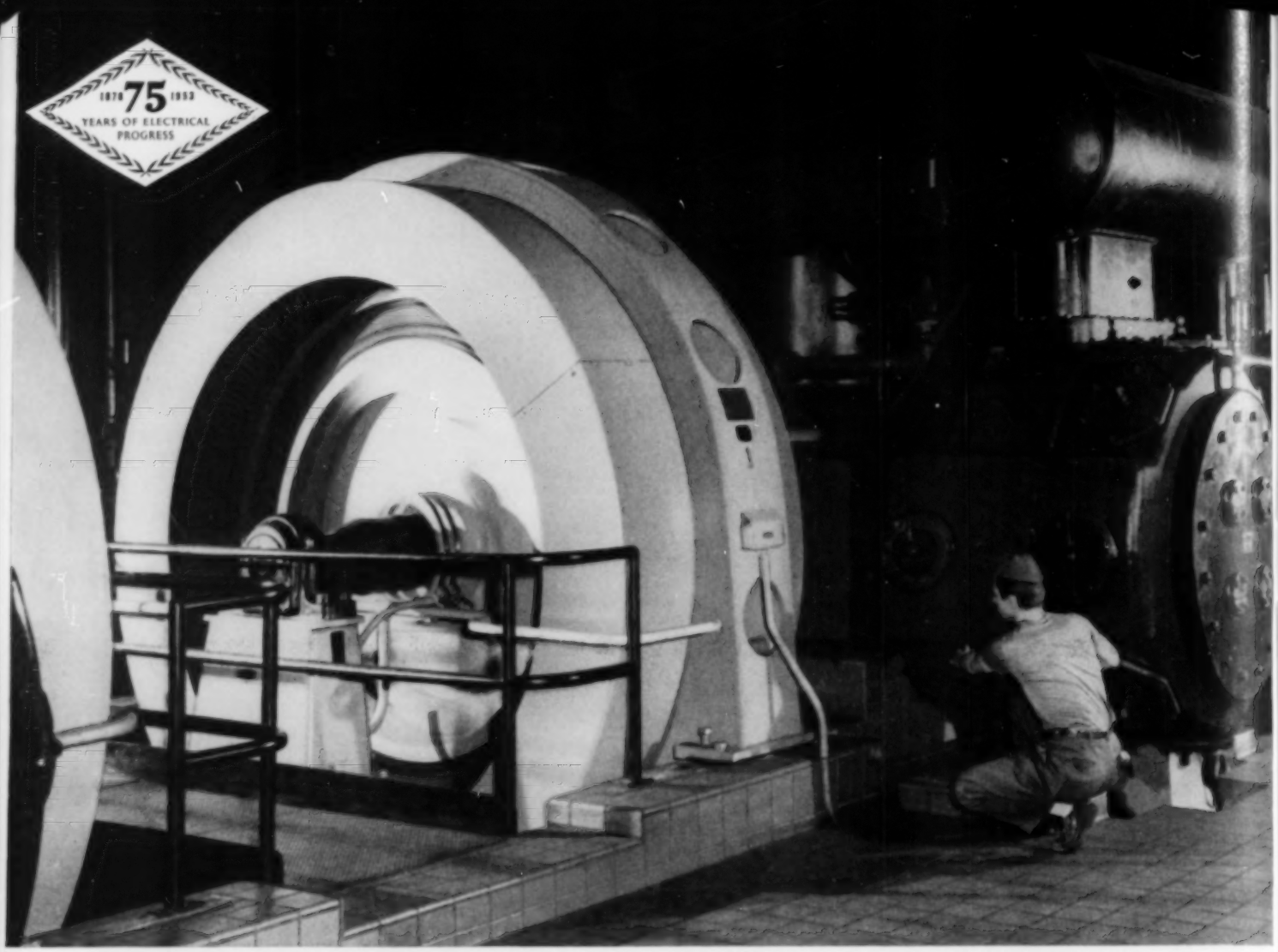

ONE OF FIVE 2000-HP G-E SYNCHRONOUS MOTORS USED FOR AIR-COMPRESSOR DRIVES AT FORD MOTOR CO., ROUGE PLANT.

FOUR REASONS WHY G-E SYNCHRONOUS MOTORS

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The welded steel-plate stator frame provides maximum rigidity in a comparatively lightweight construction. The sturdy channel-shaped frame consists of a wrapper plate firmly secured by continuous welds to rigid side plates. This design, proved by years of operating experience, affords more than ample strength for clamping and supporting the stator core.

2. G-E BRUSHES ON G-E MOTORS . . .

Brushes on G-E synchronous motors are a product of G-E teamwork. Close co-operation between machine designers and laboratory engineers means you get the right brush on the right motor for your particular application. In addition to extensive research and testing, all new and improved grades of brushes are thoroughly field-tested before approved for standard use.

Dependable G-E Synchronous Motors on 24-Hour Assembly-line Service

Ford Motor Company uses G-E synchronous motors for air-compressor drives

Compressor-motor dependability is really put to test on 'round-the-clock service at Ford Motor Company's Rouge plant. Compressed air is used 24 hours a day on many assembly operations, and a dependable supply is vital to keep production lines moving.

To furnish this all-important air, five 2000-hp G-E synchronous motors drive reciprocating compressors continuously—with only slight reductions in demand on certain shifts.

G-E synchronous motors can be relied upon for such continuous service with minimum downtime. You can depend on them because in back of every G-E synchronous motor stand more than half a century of motor engineering leadership . . . superior research and testing facilities to assure excellent component materials . . . and a corps of experienced craftsmen who are proud of the equipment they build—and build it to last.

The next time you consider a drive for heavy, continuous-service equipment be sure to call in your G-E representative to discuss any special application problem you may have. Have him explain the many money-saving uses for G-E synchronous motors and point out their operating economies.

In the meantime, you can obtain more information on G-E synchronous motors by writing for these publications: GEA-5332, "Low-speed Synchronous Motors," or GEA-5426, "High-speed Synchronous Motors." Write to Section 770-29, General Electric Co., Schenectady 5, N. Y.

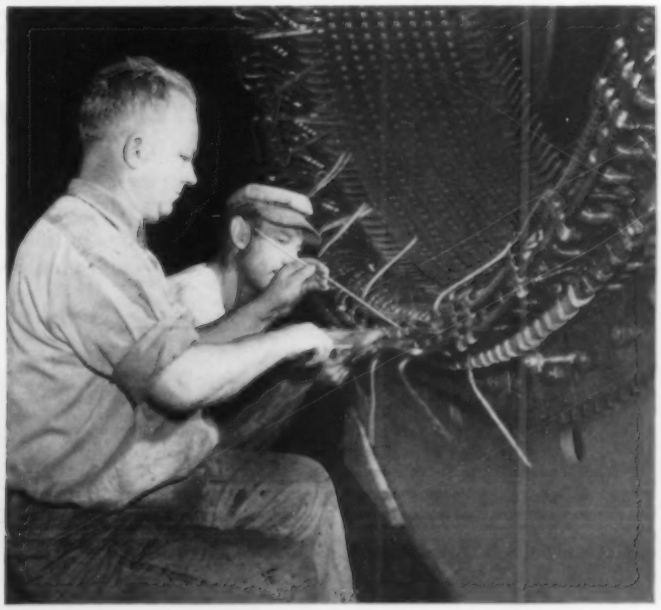
You can put your confidence in—

GENERAL ELECTRIC

GIVE LONG, DEPENDABLE SERVICE . . .

3. LONG INSULATION LIFE . . .

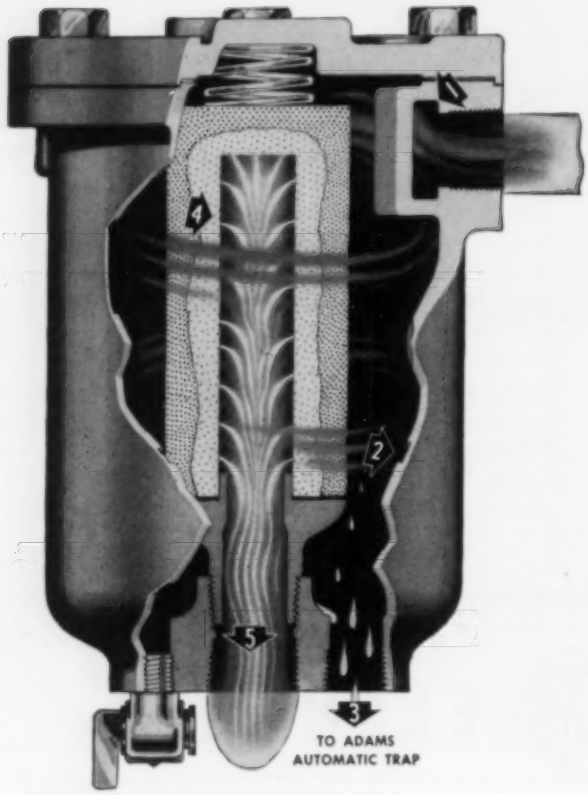
Insulating materials, manufactured in our own factories by the most modern methods, conform to rigid G-E specifications and are applied by experienced operators, above. Thus coils are uniform, interchangeable, mechanically rugged, and moisture resisting.



4. LOW-RESISTANCE CONNECTIONS . . .

For dependable operation, stator windings are silver brazed, as shown above. Joints of this type have low electrical resistance, exceptional thermal and mechanical strength. These important properties are difficult to obtain by other methods.

ADAMS *has both* *



—— BOTH ANSWERS TO THE PROBLEM OF KEEPING WATER, WATER VAPOR, OIL AND DIRT OUT OF COMPRESSED AIR LINES

There's no *one* answer to this problem! The most expensive aftercooler you can buy will not remove scale that is picked up in the distribution lines. The most expensive air filter you can buy cannot guarantee removal of water vapor until it has been condensed by cooling. That's why Adams makes both.

* PORO-STONE *AIR FILTER*

1. Centrifugal separation of dirt and liquids.
2. Drainage to trap directed by vertical cast-in slots.
3. Continuous, fully automatic trap action.
4. Rapid diffusion and filtration through permanent, cleanable Poro-Stone.
5. Clean, dry air at practically unchanged pressure. Standard, stocked sizes handle from 10 to 700 cfm.

Easily installed in either vertical or horizontal pipe line.

* AFTERCOOLER AND CYCLONE SEPARATOR

Cools air to within a few degrees of cooling water, making certain that compressed air is colder than surrounding atmosphere, so that no further condensation can take place.

Counter flow, air-through-tube design assures continuously high heat transfer rate.

Double cyclonic action deposits all water and entrained oil in moisture chamber.

R. P. ADAMS CO., INC.
209 E. Park Drive, Buffalo 17, New York

Please send me your latest literature, Bulletin No. 176 on BOTH the Poro-Stone air filter and the Adams Aftercooler — Cyclone Separator.

Name.....

Company..... *Title*.....

Address.....

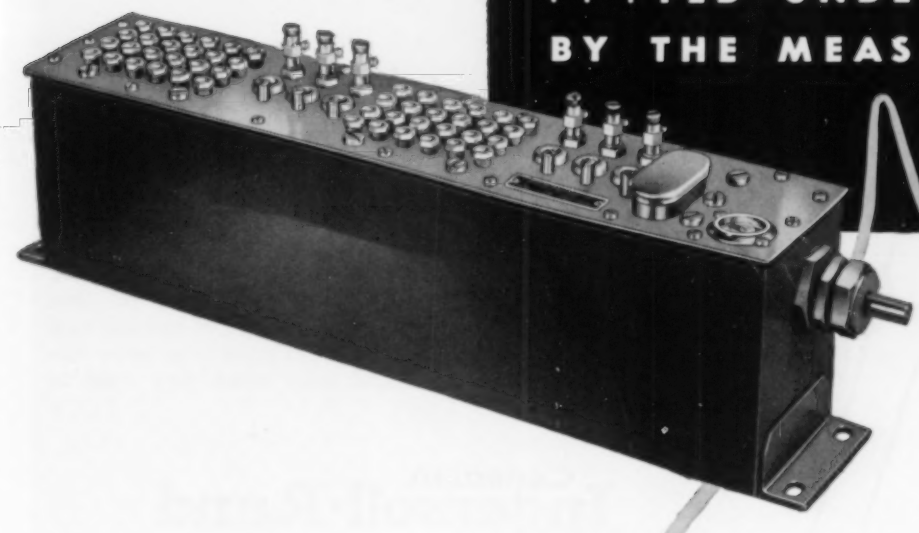
City..... *State*.....

FOR YOUR PROFIT'S SAKE — FIND OUT ABOUT BOTH

R. P. ADAMS CO., INC., BUFFALO 17, N. Y.

MADISON-KIPP *Fresh Oil*

. . . FED UNDER PRESSURE BY THE MEASURED DROP



the most dependable method of lubrication ever developed!

This lubricator becomes an integral part of a machine tool in which there are 48 vital bearings that require dependable lubrication. The Madison-Kipp mechanism is so compact that the reservoir measurements are only 4" wide, 19¾" long by 5¾ high."

There are six different models to meet almost every application requirement. Please write us for all details regarding your particular lubricator requirements.

MADISON-KIPP CORPORATION
202 WAUBESA STREET • MADISON 10, WISCONSIN

kipp

• Skilled in Die Casting Mechanics • Experienced in Lubrication Engineering • Originators of Really High Speed Air Tools

ELECTRIC MINE HOISTS

...by Canadian Ingersoll-Rand

Mine hoist installations require the closest cooperation between mine engineering staff and the engineers of the hoist manufacturer. For example, the hoist shown here had to be built in special sections to allow for transit underground through existing openings.

Canadian Ingersoll-Rand hoist engineering staff has the benefit of nearly seventy years of hoist manufacturing experience to draw upon — experience that has resulted in installations in practically every type of mining and in all parts of the world. This experience is at your disposal. Call an Ingersoll-Rand man when you want to talk about hoists.

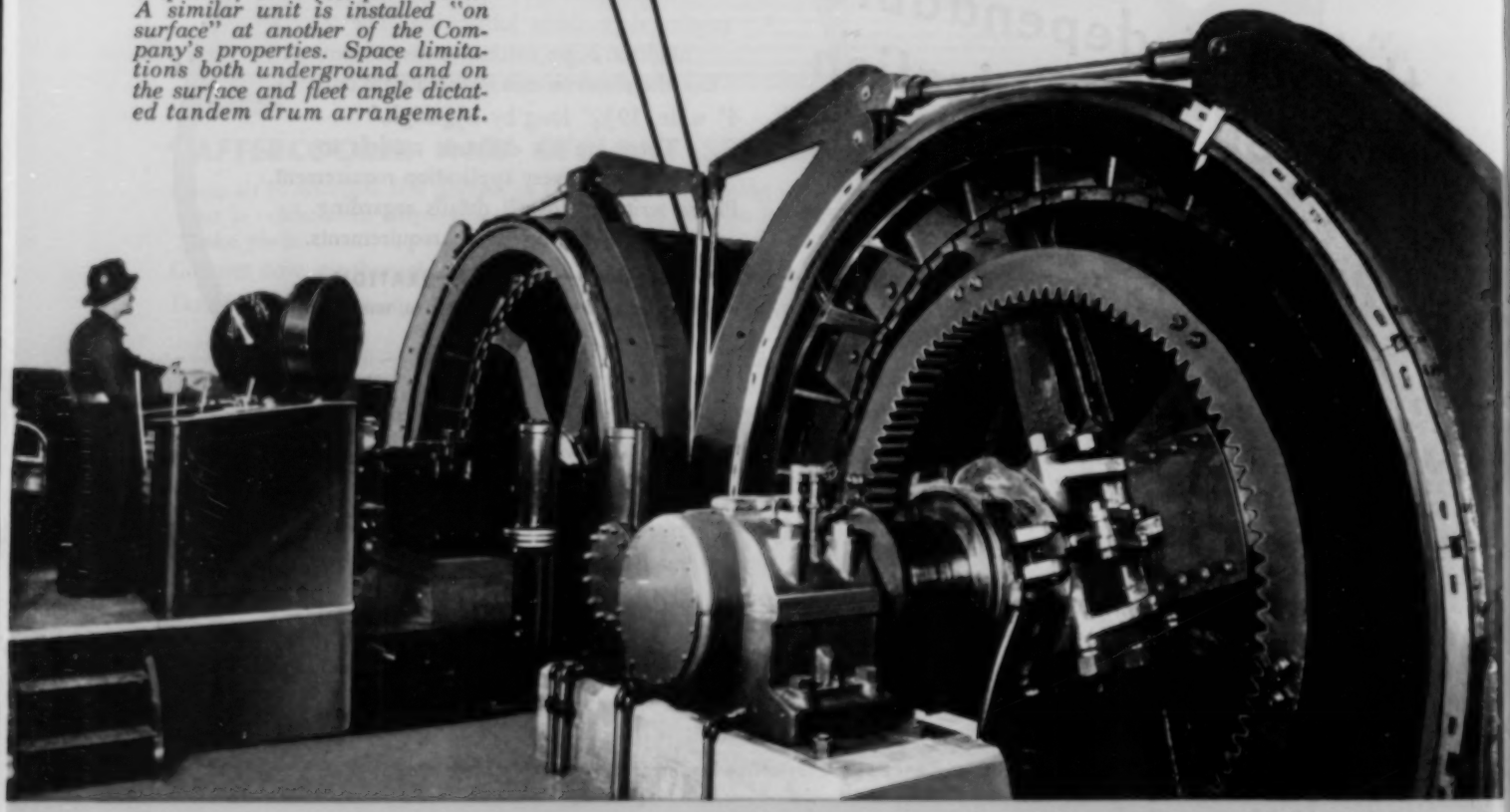
CANADA

Canadian Ingersoll-Rand Company Limited

HEAD OFFICE MONTREAL, QUE. . . WORKS SHERBROOKE, QUE.

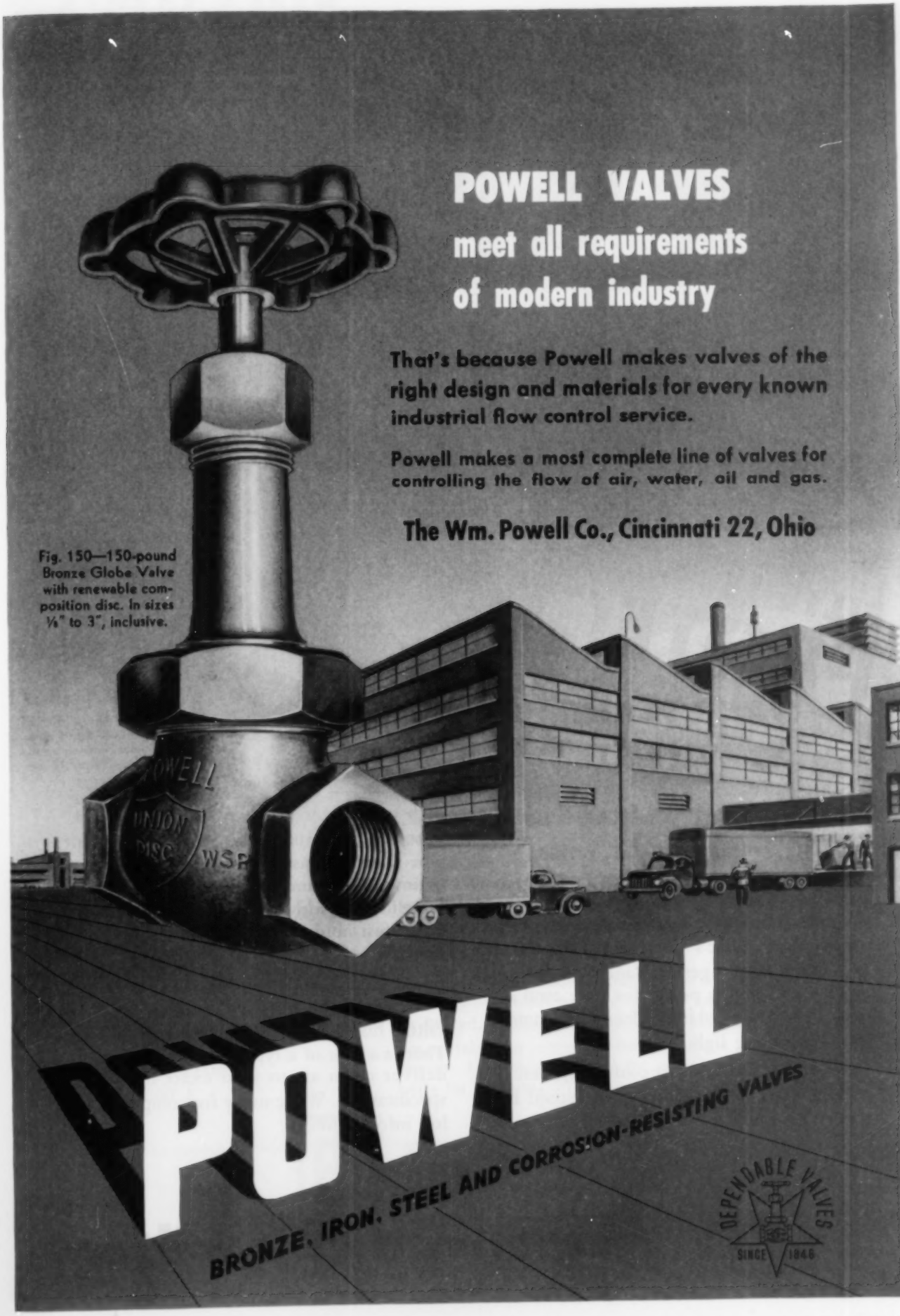
SYDNEY - SHERBROOKE - MONTREAL - TORONTO - KIRKLAND LAKE - TIMMINS - WINNIPEG
CALGARY - NELSON - VANCOUVER

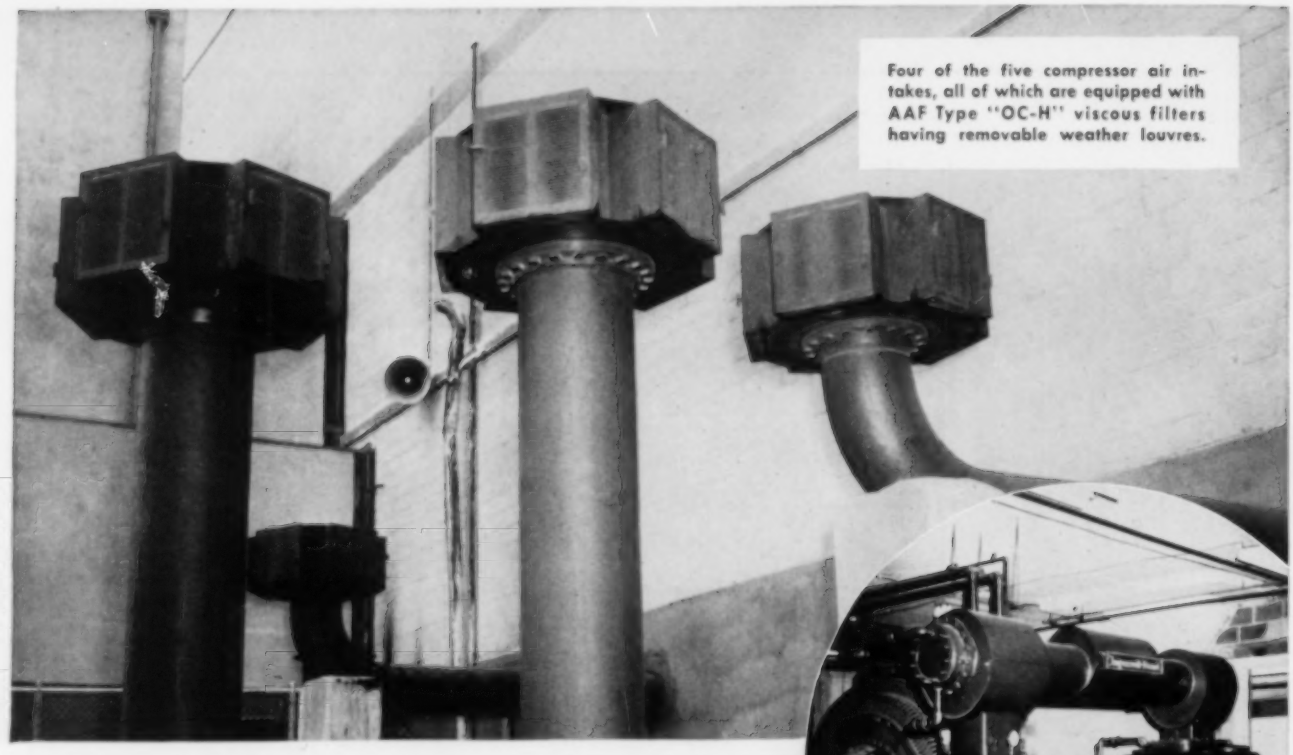
This 55,000 lb. rope-pull tandem-drum unit is installed underground at one of the mines of the International Nickel Company. The hoist is designed to raise men and materials four thousand feet at a speed of 1500 feet per minute. A similar unit is installed "on surface" at another of the Company's properties. Space limitations both underground and on the surface and fleet angle dictated tandem drum arrangement.



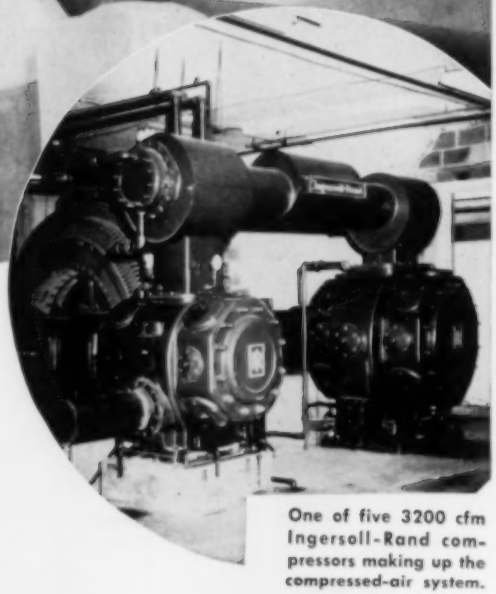
OVER SIXTY YEARS OF EXPERIENCE BUILT INTO EVERY HOIST

K-31


POWELL VALVES
meet all requirements
of modern industry
That's because Powell makes valves of the right design and materials for every known industrial flow control service.
Powell makes a most complete line of valves for controlling the flow of air, water, oil and gas.
The Wm. Powell Co., Cincinnati 22, Ohio
Fig. 150—150-pound Bronze Globe Valve with renewable composition disc. In sizes ⅛" to 3", inclusive.
POWELL
BRONZE, IRON, STEEL AND CORROSION-RESISTING VALVES
DEPENDABLE VALVES
SINCE 1846



Four of the five compressor air intakes, all of which are equipped with AAF Type "OC-H" viscous filters having removable weather louvres.



One of five 3200 cfm Ingersoll-Rand compressors making up the compressed-air system.

FILTERS PROTECT TANK PLANT against air raids from dust

AAF "OC-H" Filters Stand Guard Over Compressed-Air System Serving More Than 2000 Tools

Compressed air is a mighty important commodity at Cadillac's Cleveland Tank Plant. Five 3200 cfm Ingersoll-Rand compressors provide the motive power for over 2000 air-tools and hoists used in producing the famous Walker Bulldog light tanks.

What havoc dust and dirt could play, here, if allowed free access to this vital system! But they're "stopped cold" at the air intake of each compressor by an AAF Type "OC-H" Filter. Selection of this viscous impingement type filter was based on several factors—ease of installation and maintenance, high cleaning efficiency with low resistance to air flow, large dust holding capacity and rugged construction.

Every engine and compressor user should make "clean air" a defense project—and AAF Filters his first line of defense against dust. There's a unit of a type and size designed to deliver clean air to your exact needs and specifications. Write today for complete catalog information.

AAF

American Air Filter
COMPANY, INC.

402 Central Avenue, Louisville 8, Kentucky • American Air Filter of Canada, Ltd., Montreal, P. Q.

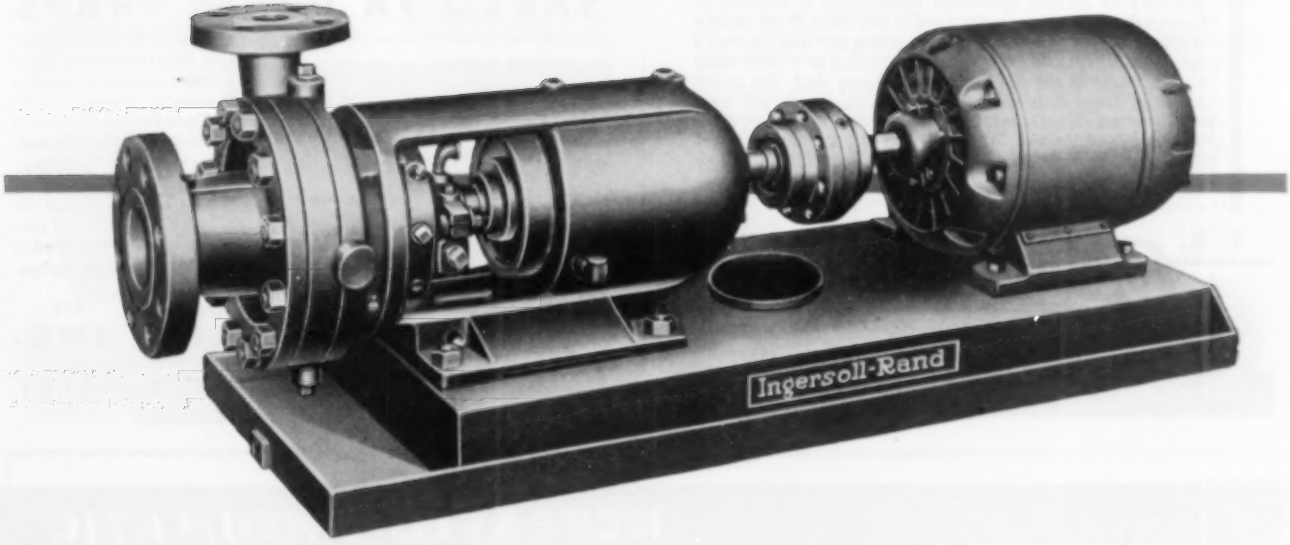
a **NEW LINE** *of Ingersoll-Rand pumps*

★ **FOR MEDIUM-DUTY REFINERY AND PROCESS SERVICE**

★ **WITH "HEAVY-DUTY" FEATURES**

★ **FOR EXTRA DEPENDABILITY**

★ **WITH REDUCED MAINTENANCE**



CLASS AFL

SIZES:
1, 1½, 2 and 3 inches

CAPACITIES:
20 to 550 gpm

PRESSURES:
to 300 lb

TEMPERATURES:
to 500° F

This line of *new* single-stage, vertically split pumps incorporates many important design features formerly available only in larger, more costly heavy-duty units.

Class AFL pumps feature a heavy steel casing with Series 300 A.S.A. raised-face flanges. The single-suction impeller, specially designed to handle volatile liquids, is attached to the *ground and polished shaft* with the same positive locking device used in heavy-duty pumps. A hooked-type shaft sleeve, sealed against leakage, permits uniform expansion at high temperatures.

The deep, water-cooled stuffing box can be arranged for either conventional packing or for a mechanical shaft seal, as desired. Equipped with gear-type couplings, AFL pumps are suitable for either motor or turbine drive. Call your nearest I-R representative for complete information – or write for Bulletin 7277.

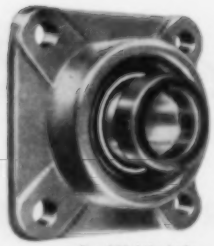
Ingersoll-Rand

943-10

CAMERON PUMP DIVISION
11 Broadway, New York 4, New York

Compressors • Turbo-Blowers • Vacuum Equipment • Rock Drills • Gas and Diesel Engines • Air and Electric Tools

No. 200 Life-Lube Pillow Block



No. 201 Life-Lube Flange Unit

reduce maintenance costs with WOOD'S LIFE-LUBE bearing units

Absolutely no periodic lubrication maintenance is required on Wood's Life-Lube bearing units. They're lubricated at our factory for life. Now, you can do away with the grease gun and the man's time behind it because a synthetic seal (bonded to a steel core) keeps lubricant in and dirt out. Ideal for heavy dust, dirt or lint conditions. These units are of modern design, sturdy and compact. Standard 200 series MRC ball bearings with wide, deep ball race groove sustains the radial load and substantial thrust either way. For further information, write for Bulletin 194 or consult your Wood's Industrial Distributor.

T. B. Wood's SONS COMPANY

CHAMBERSBURG, PA.

Mechanical Power Transmission Manufacturers—Since 1857.

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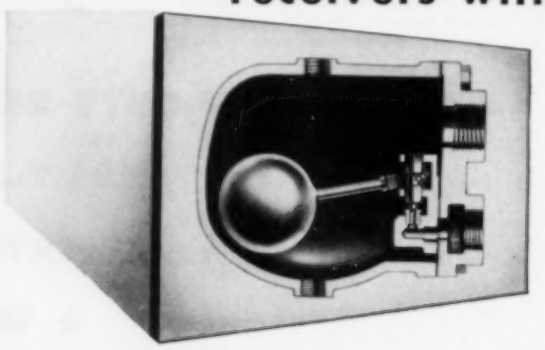
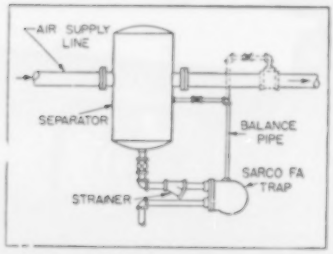
Drain compressed air receivers with



SARCO FA DRAIN TRAPS



Type FA Trap draining separator.

...also your intercoolers, aftercoolers and separators. These traps automatically release condensate as it forms... without the waste of air that occurs when blowdown valves are used. New technical bulletin No. 5-CA offers many suggestions as to how you can increase the EFFECTIVE capacities of your air compressors. Write today for your free copy. No obligation... of course.

513

sarco COMPANY, INC.

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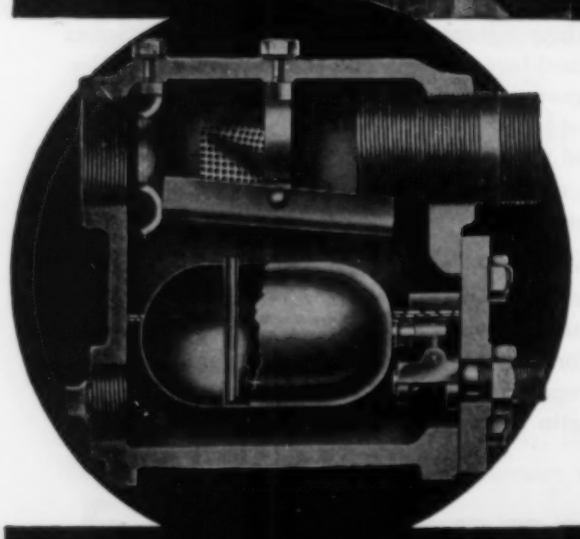
SARCO CANADA, LTD., TORONTO 5, ONTARIO

DRI AIR MAY BE INSTALLED BY SUSPENDING IT FROM THE PIPING WITHOUT ANY OTHER SUPPORT.

INCREASED PNEUMATIC EFFICIENCY WITH THIS AUTOMATIC SEPARATOR



PROTECT EQUIPMENT WITH

DRIAIR

SEPARATES • COLLECTS • DELIVERS

• DriAir separates and automatically ejects the condensed water and oil from compressed air lines, collects pipe scale and rust, delivers clean dry air to tools and other pneumatic equipment. This promotes better lubrication, reduces wear, increases life of tools and produces greater output. All internal parts are made of bronze or copper—resistant to corrosion and practically permanent.

A TYPICAL INSTALLATION SHOWING DRI AIR STANDING ON A CONCRETE FLOOR NEXT TO THE WALL.

WRITE FOR BULLETIN DA WHICH FULLY DESCRIBES THE CONSTRUCTION AND OPERATION OF THE DRIAIR.

NEW JERSEY METER CO.

"SPECIALISTS IN COMPRESSED AIR DEVICES"

PLAINFIELD, NEW JERSEY

FOR BETTER SERVICE *specify...*

COOK
ROD PACKING RINGS

STYLES FOR EVERY COMPRESSOR SERVICE

DELIVERY FROM STOCK

MATERIALS FOR EVERY CONDITION

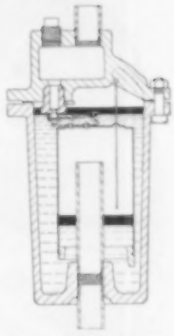
Cook Graphitic Iron Plain or Tinized • Cookmet (Bronze) • Babbitt • Carbon • Cookroc (Bakelite) plain or graphitized • Hi-Temp Cookroc (Bakelite)

Write for Catalog No. 440

C. LEE COOK MFG. CO.
INCORPORATED
Dept. 1, LOUISVILLE 3, KY.

THIS AIR TRAP
is not stopped by oil

NOW you can get dependable, automatic drainage of water from compressed air intercoolers, aftercoolers, receivers and separators even though the compressor is pumping heavy oil. Any oil reaching Armstrong Inverted Bucket Air Traps collects at the top and is discharged ahead of the water.



Inverted Bucket Air Traps.
Side-inlet side-outlet styles available.

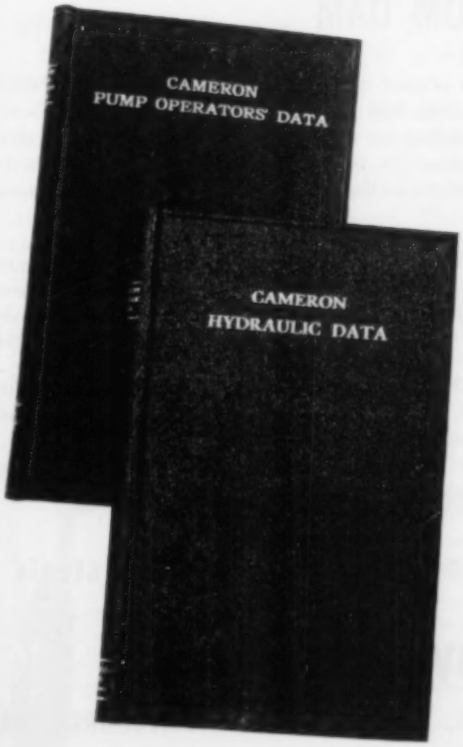
Armstrong Air Traps have a simple, proven design; there's nothing to stick, bind or clog. Stainless steel mechanism resists corrosion. For pressures to 600 lbs. *Guaranteed to Satisfy.*

ARMSTRONG MACHINE WORKS
885 Maple Street • Three Rivers, Michigan

SEND FOR FREE BULLETIN No. 2021 GIVING DETAILS

Manufacturers of the well known ARMSTRONG STEAM TRAP

TWO HANDY REFERENCE BOOKS



For
The Engineer, The Superintendent, The Operating Man

CAMERON PUMP OPERATORS' DATA (Second Edition): Contains practical information covering the installation, operation and maintenance of centrifugal pumps.

CAMERON HYDRAULIC DATA (Twelfth Edition): Covers data useful in work involving the handling of liquids, steam, and water vapors.

Both books can be obtained at the combination price of $4.50.

PRICE INDIVIDUAL BOOKS PER COPY.

Cameron Pump Operators Data..... $2.00
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Phillipsburg, New Jersey, U.S.A.

PLEASE SEND ME:

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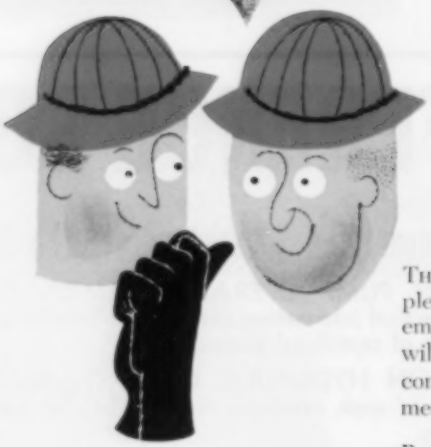


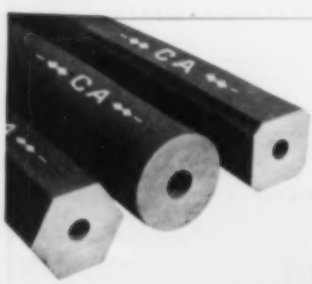
they're using

CRUCIBLE HOLLOW DRILL RODS at FOLSOM DAM

THE FOLSOM DAM project is a big construction job. When completed it will be 340 feet high, 1400 feet long – with wing embankments extending for more than two miles. The new dam will provide a source for irrigation and power, and serve to control flood conditions in the American River Basin near Sacramento, California.

Part of the construction work involves the excavation of more than 9 million cubic yards of earth and rock. Here's where Crucible Hollow Drill Rods are playing a mighty important role. They can't be beat when it comes to hard rock drilling operations.

Crucible Hollow Drill Rods are made to tool steel standards by the world's largest producer of tool and other special purpose steels. This *extra* quality assures you of minimum rod breakage . . . and fewer valuable bit losses. For dependability in rock drilling, buy Crucible Hollow Drill Rods.



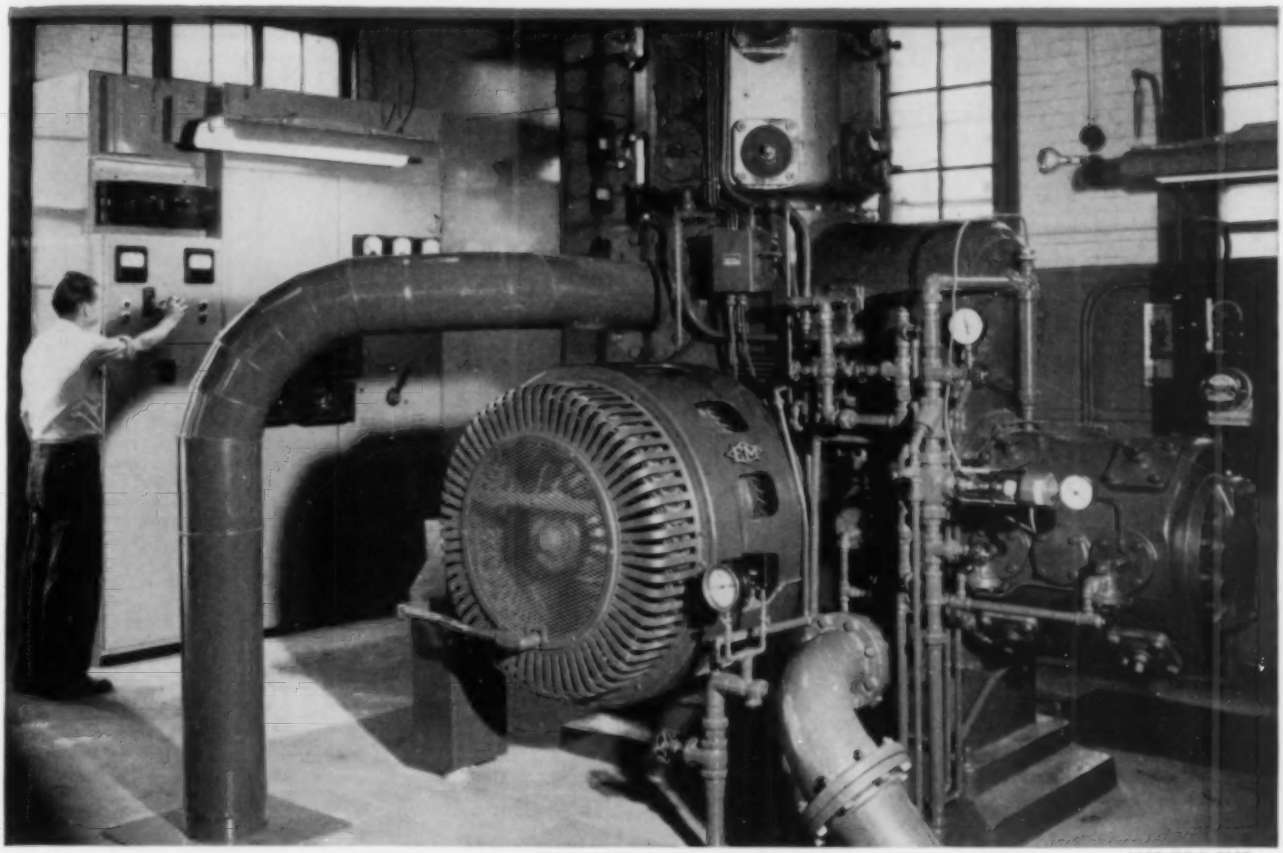
CRUCIBLE first name in special purpose steels

53 years of Fine steelmaking

HOLLOW DRILL ROD

CRUCIBLE STEEL COMPANY OF AMERICA, GENERAL SALES OFFICES, OLIVER BUILDING, PITTSBURGH, PA.

REX HIGH SPEED • TOOL • REZISTAL STAINLESS • ALLOY • MACHINERY • SPECIAL PURPOSE STEELS



1100-TPA-2115

How to Make Compressors Take up Less Space

Want to save some valuable floor space?

Here's how it is done on the air compressor drive installation above:

The compressor is driven by a 200 hp, 514 rpm E-M Synchronous Motor, overhung mounted. Stator and rotor are mounted directly on compressor frame and crankshaft. Motor bearings as well as losses from belt drives and couplings are eliminated. The drive motor thus becomes a compact, integral part of the entire compressor unit.

You'll save space on any compressor with a direct-connected E-M Synchronous Motor. E-M engineers possess a unique background of experience in tailoring Synchronous Motor characteristics to drive requirements of every type of compressor. This skill, plus E-M's knack for condensing drive units into least possible space, should be considered when you plan your next compressor installation.

Also, you'll find that E-M Synchronous Motors can improve plant power factor and reduce power costs. For example, an E-M Motor rated at 0.8 leading power factor will furnish sufficient leading reactive KVA to correct a low power factor condition which may be caused by demands of other plant equipment.

Ask your nearest E-M sales engineer to demonstrate how these E-M benefits can be applied to your specific requirements. And write the factory for E-M Synchronizer No. 32, the air compressor number.

...the man at the controls

starts, stops and protects the motor with E-M special feature Controls... magnetic, for automatic operation... full-voltage, for economical starting... dead-front panels for maximum safety ... overload and undervoltage protection ... and the exclusive E-M Polarized Field Frequency Relay system, simplest and most ingenious method ever developed for perfect synchronizing.

ELECTRIC MACHINERY MFG. COMPANY

MINNEAPOLIS 13, MINNESOTA

E-M

POWER THAT THINKS...E-M SYNCHRONOUS MOTORS AND "CONSCIOUS" CONTROLS

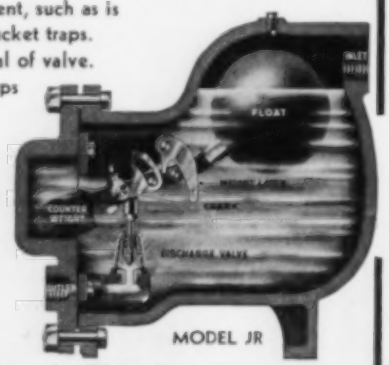
Solve Sludge Problem with Nicholson's

New AIR TRAPS

With the introduction of an exclusive new oil-eliminating feature that prevents build-up of scum and sludge, Nicholson air traps now enable you to enjoy the advantages of the positive intermittent action of a float-operated air trap without the common problem of oil congealing on the mechanism and impeding or stopping its action. Other features of Nicholson air traps:

1) No air-wasting vent, such as is in all inverted bucket traps.
2) Positive water seal of valve.
3) Large orifice keeps valve clean, preventing blow-through. Three types; pressures to 1500 lbs. For details send for

CATALOG 751



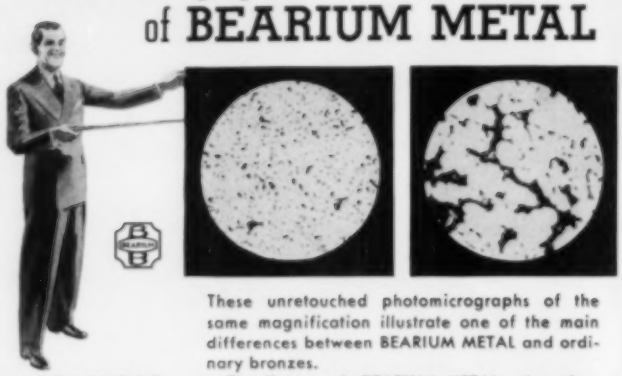
MODEL JR

180 Oregon St., Wilkes-Barre, Pa.

W. H. NICHOLSON & CO.

TRAPS · VALVES · FLOATS

Photomicrographs Prove Superiority of BEARIUM METAL



FEATURES

Non-Seizing and Non-Scoring • Long Wearing • Self Lubricating • Low Coefficient of Friction • High Compressive Strength • Resistant to Shock Loads • Sound, Uniform Structure • Free-Cutting.

These unretouched photomicrographs of the same magnification illustrate one of the main differences between BEARIUM METAL and ordinary bronzes.

The first one is BEARIUM METAL—the other, taken under identical conditions represents a typical sample of ordinary bronze. Note how in BEARIUM METAL alone the lead particles (black areas) are in microscopic, globular form and uniformly distributed. Note also total absence of lead between the copper-tin grain boundaries in BEARIUM METAL. No fluxes or other ingredients are used to accomplish this. As a result, BEARIUM METAL contains no "hard spots" to score the shaft or interfere with machining.

Write for Detailed Information Today!

BEARIUM METALS CORP.

270 State St., Rochester 14, N. Y.

WEST COAST AFFILIATE:
Nevin Engineering Associates
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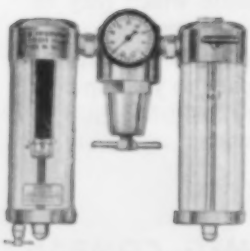
IN CANADA:
Bearium Metals of Canada, Ltd.
155 George St.
Toronto 2, Canada

Prominent User Acclaims

"M-B" Automatic Air Line FILTER, REGULATOR and LUBRICATOR Assembly



The value of "M-B" Automatic Air Line Filters, Regulators and Lubricators is widely known for their effectiveness as a protection to Air Valves, Cylinders, Pneumatic Tools, etc.

"Your 'Sentinel of the Air Line' has been giving us very good service. We have had no complaints at all and I trust that we will be ordering more of them in the near future."

signed: **A. E. Cranston, Sr.**
PRESIDENT

Cranston Steel Strapping Co.
Oak Grove, Oregon

WRITE FOR LITERATURE

M·B PRODUCTS
46 Victor Ave.
DETROIT 3, MICHIGAN

REDUCE BULK STORAGE LABOR AND EXPENSE...

with a

SAUERMAN SCRAPER SYSTEM

Versatile one-man units readily adapted to any storing and reclaiming project . . . large or small . . . almost any size or shape . . . indoors or outdoors.

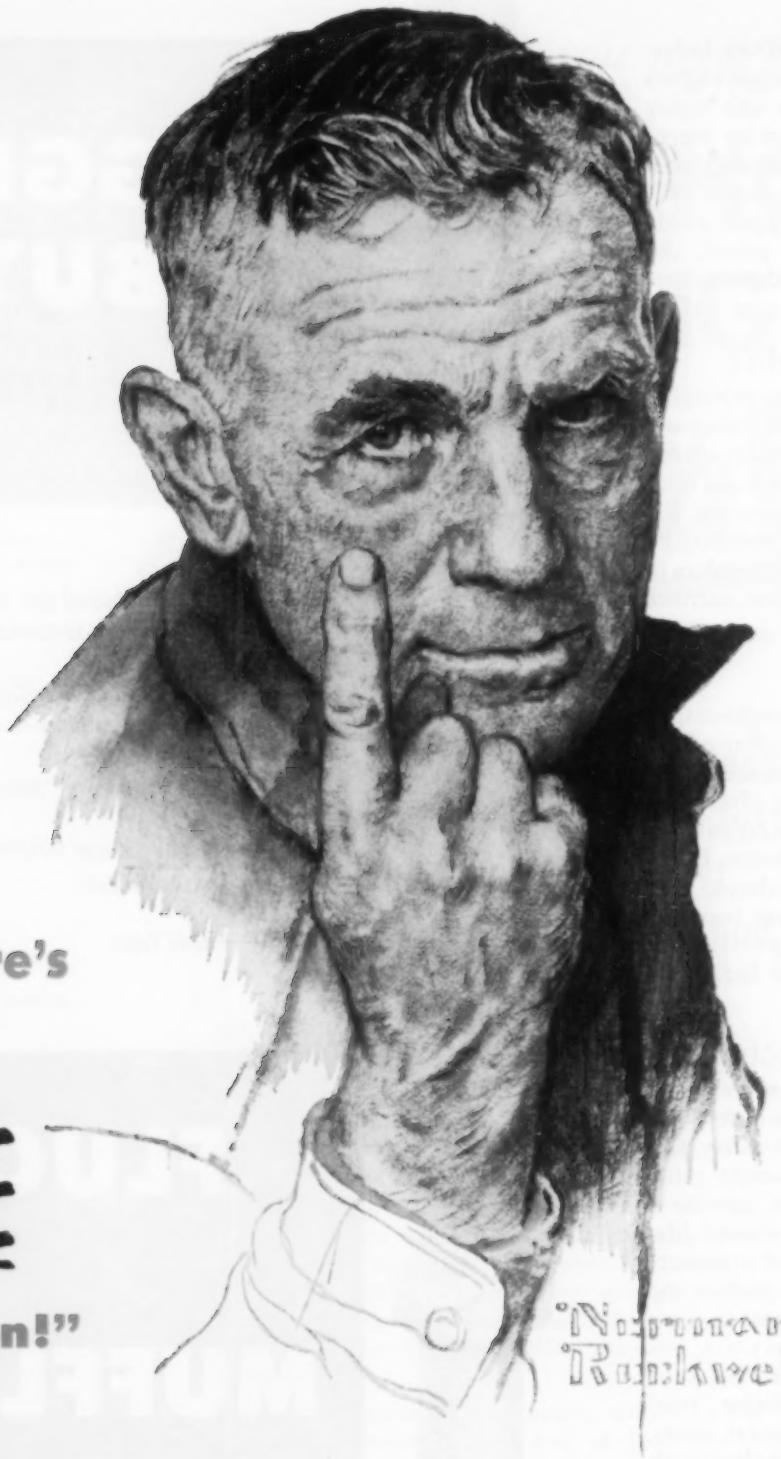
- **Range: up to 1000 ft.**
- **Bucket Sizes: 1/3 to 15 cu. yds.**
- **For Handling: ore, stone, coal, etc.**
- **Speed, In-haul: 250 fpm.**
- **Speed, Out-haul: 500 fpm.**
- **Control: one-man operated.**
- **Power: gasoline, diesel, electric.**

Find out more about time-saving, money-saving Sauerman Scrapers. Write today for free, illustrated catalog on bulk handling methods.

SAUERMAN BROS. Inc.
548 S. Clinton St.
Chicago 7, Ill.

Photo shows Sauerman Scraper stocking out coal at large power plant. Building a high, compact pile 350 ft. in radius, this scraper stores and reclaims at rate of 250 tph.

Sauerman Scraper stores wet phosphate rock in high, wide pile alongside drying plant, then reclaims rock as shown in picture after drainage has taken place.



"There's only ONE reason!"

IT'S JUST THAT SIMPLE. There's only one reason in the world why so many wire rope users in the excavating and construction field prefer Roebling wire rope . . . *it costs a lot less on the job than any other.*

For maximum wire rope efficiency and economy, call your nearest Roebling office for a Field Man. He'll recommend the best ropes for your machines.

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BIGGEST BUY in mufflers today!

THE NEW Fluor Heavy-Duty Industrial Muffler for 2 and 4-cycle engines incorporates in a single unit highly efficient acoustic elements for silencing engine and compressor exhaust and intake noise. The Series "C" Muffler is compact, rugged, easily installed, competitively priced, and is recognized for these three important design features:

high sound attenuation

Utilizing acoustical filter principles, Fluor mufflers efficiently attenuate both low and high-frequency sounds with minimum resistance to gas flow. By suppressing pipe resonance, the unique, deresonating "fishmouth" entrance allows complete freedom in muffler placement without sacrifice of performance.

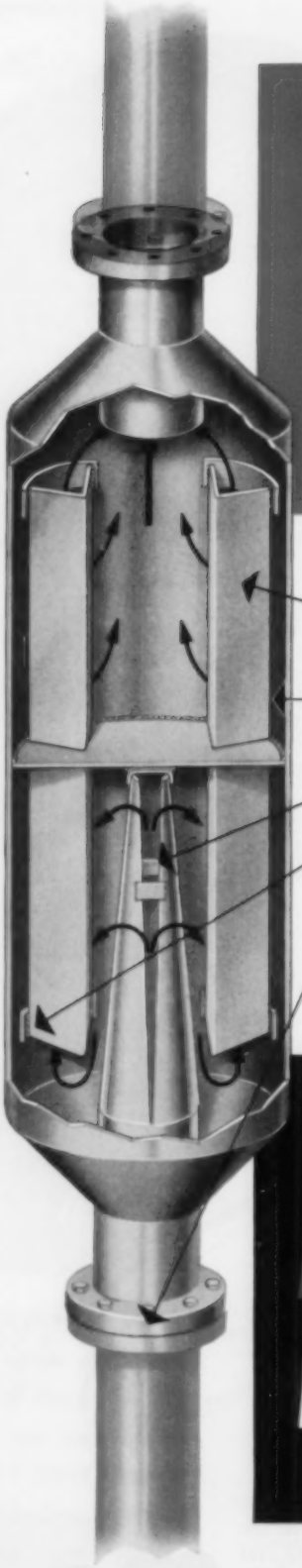
low back pressure

The Fluor-engineered, angle-shaped gas passages in the muffler afford significantly lower resistance to gas flow, for a given acoustic effect, than do mufflers having interchamber tubes of conventional design. Better fuel economy, lower exhaust temperatures with consequent improvements in engine longevity, are dividends yielded by low back-pressure Fluor mufflers.

engineered construction

Long experience in pressure vessel design and construction is reflected in Fluor mufflers. High safety factors, high strength-to-weight ratio, and superior fabrication, provide a long trouble-free operational life. Freely-venting internal structure eliminates explosive gas pockets and susceptibility to explosions.

For other Fluor Acoustic Products—Ventilating Mufflers utilizing "free" kinetic energy of exhaust gases, mufflers for special applications, pulsation dampeners—consult your nearest Fluor office.



Angle-shaped gas transfer passages with large cross-sectional areas.

Continuous bleeder slots along edges of angles.

Deresonating "fishmouth" entrance Tube.

Heavy gauge welded construction

Gas Inlet.

FLUOR heavy-duty Series "C" MUFFLERS

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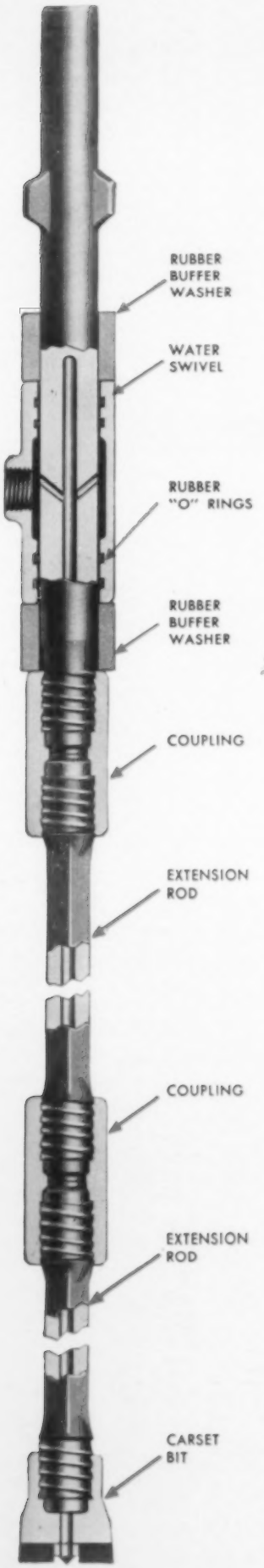
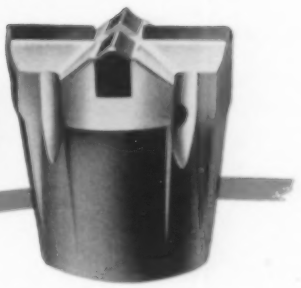


Everything you need for

LONG HOLE DRILLING

WITH

Carset Jackbits



Holes up to 100 feet deep are now being drilled faster and at much lower cost by this I-R Carset method

The longer-lasting, faster-drilling Carset Jackbit, with practically no gauge wear, has revolutionized deep hole drilling with I-R Drifters and coupled steels. The Carset method is not only much faster, but less costly than when using diamond drills. No special training is needed and the work can be done by regular miners with a minimum of supervision.

To permit the most efficient deep hole drilling with I-R Drifters and Carset bits, Ingersoll-Rand has developed and perfected a *complete line* of accessory equipment—including a water swivel that feeds hole cleaning air and water at high pressure directly into the drill steel without going thru the drill—a rugged, long-lasting coupling with the same threads as the bits—and extra-strong alloy steel extension rods.

This combination of equipment, shown at the left, has proved remarkably successful in a host of deep-hole drilling applications. Ask your nearest I-R representative for the complete story. He can supply *everything you need*—from the bit all the way back to the compressor.

Ingersoll-Rand
11 BROADWAY, NEW YORK 4, N. Y.

COMPRESSORS • AIR TOOLS • ROCK DRILLS • TURBO BLOWERS • CONDENSERS
CENTRIFUGAL PUMPS • DIESEL AND GAS ENGINES

954-15

Compressor powers powerhouse gauges

...with help of TIMKEN® bearings

THIS Connecticut power company's Devon Station relies on Ingersoll-Rand's ES-1 compressor to deliver instrument and gauge air 24 hours a day without fail.

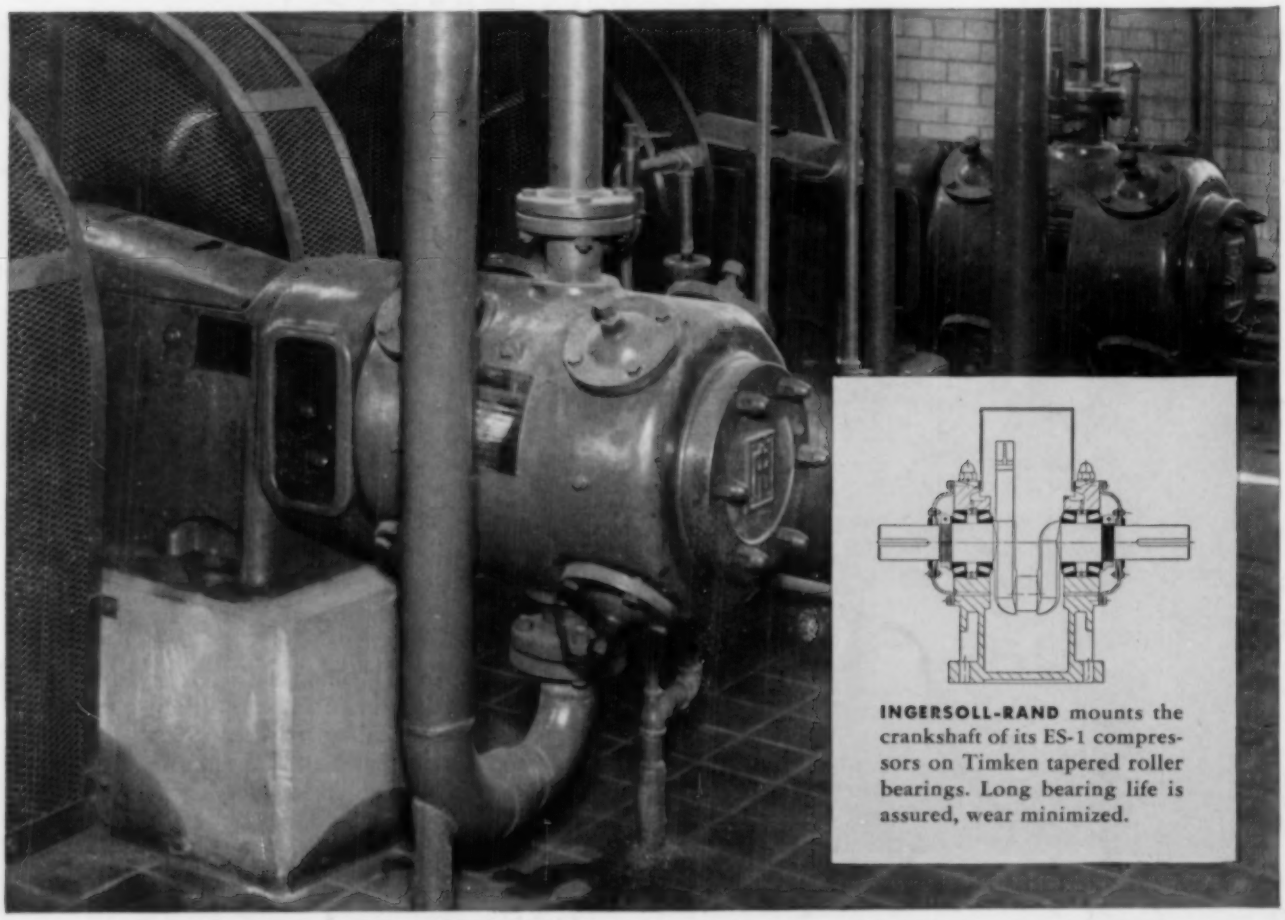
One reason they can place so much confidence in the compressor is that its crankshaft is mounted on Timken® tapered roller bearings.

Timken bearings normally last the life of the compressor. Besides, they help other parts last longer by keeping the crankshaft in proper alignment.

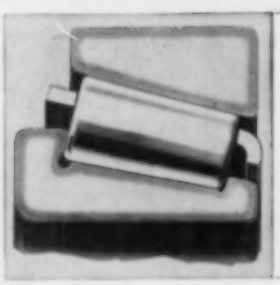
The tapered design of Timken bearings gives them the ability to carry both radial and thrust loads in any combination. Extra thrust bearings are eliminated—less maintenance is needed. And Timken bearings' true rolling motion and smooth surface finish practically eliminate friction.

If you want dependable low-cost operation and long life in the machines you use or make, always be sure they're equipped with Timken bearings. Look for the trademark "Timken" on every bearing. The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO".

This symbol on a product means its bearings are the best.



INGERSOLL-RAND mounts the crankshaft of its ES-1 compressors on Timken tapered roller bearings. Long bearing life is assured, wear minimized.



HARD ON THE OUTSIDE, TOUGH ON THE INSIDE

Rollers and races of Timken bearings are case-carburized to give a hard, wear-resisting surface and a tough, shock-resisting core. Result: longer bearing life.

The Timken Company leads in: 1. advanced design; 2. precision manufacture; 3. rigid quality control; 4. special analysis Timken steels.

TIMKEN

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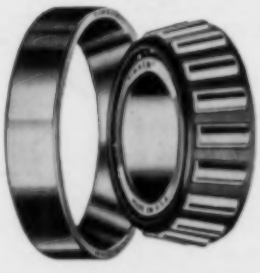
TAPERED ROLLER BEARINGS



NOT JUST A BALL ○ NOT JUST A ROLLER ⬭ THE TIMKEN TAPERED ROLLER ⬭ BEARING TAKES RADIAL ↓ AND THRUST →◎← LOADS OR ANY COMBINATION →✳←